Beatrice Offshore Wind Farm

Consent Plan

Piling Strategy

November 2015

Beatrice
Offshore Windfarm Ltd

Project Title/ Location	Beatrice Offshore Wind Farm
Project Reference Number	LF000005
Date:	November 2015

Beatrice Offshore Wind Farm

Piling Strategy

Pursuant to Section 36 Consent Conditions 12 and 34 and the Marine Licence (Offshore Transmission Works) Condition 3.2.2.5

For the approval of the Scottish Ministers

Rev	Prepared By	Sign Off	Checked By	Sign Off	Approved By	Sign Off	Date of Issue
04	RPS, GoBe Consultants Ltd., Brown and May Marine	Steve Bellew	BOWL	Johnathan Wilson	Steven Wilson, Senior PM, BOWL	[redacted]	2/11/15

[Page left intentionally blank]

Table of Contents

Consent Plan Overview

Purpose of the Plan

This Piling Strategy (PS) has been prepared to address the specific requirements of the relevant conditions attached to Section 36 Consent and Marine Licences issued to Beatrice Offshore Windfarm Limited (BOWL).

The overall aim of the PS is to present the means by which the effects of underwater noise resulting from piling activity on marine mammals and fish are to be mitigated during the construction of the Beatrice Offshore Wind Farm and Offshore Transmission Works (OfTW).

All BOWL personnel and contractors involved in the Beatrice Project must comply with the mitigation measures and procedures presented in this PS.

Scope of the Plan

The PS covers, in line with the requirements of Section 36 and Marine Licence conditions, the following:

- Details of the proposed method and anticipated duration of pile driving activities across the Development site;
- Details of the anticipated maximum hammer energy required to drive piles;
- Details of soft start piling procedures; and
- Details of the mitigation and monitoring to be employed during piling operations.

Structure of the Plan

The PS is structured as follows:

Sections 1 and 2 set out the scope and objectives of the PS and set out broad statements of compliance.

Section 3 describes how the detail of the PS will be communicated to and implemented by those involved in the Project.

Section 4 summarises the consultation undertaken to inform the development of the PS.

Section 5 details the process for making updates and amendments to the PS.

Sections 6 and 7 describe piling methods and durations, and anticipated maximum hammer energies.

Section 8 presents the environmental sensitivities that have been taken into account in developing the PS.

Section 9 explains the reduction in the Development Design Envelope relative to consented Project parameters, and the relevance of this to the PS.

Sections 10 and 11 present planned mitigation and monitoring measures to be applied during piling operations.

Section 12 summarises licensing requirements relevant to the planned piling operations.

Section 13 describes reporting requirements around piling operations.

Appendices present supporting information, including a mitigation protocol and ADD deployment procedures.

Plan Audience

This PS is intended to be referred to by personnel involved in the construction and operation of the Beatrice Project, including BOWL personnel, Key Contractors and Subcontractors. All method statements produced in relation to the Project must comply with this PS.

Compliance with this PS will be monitored by the BOWL Consents and Licensing Team, the BOWL ECoW, and the Marine Scotland Licensing and Operations Team.

Plan Locations

Copies of this PS are to be held in the following locations:

- BOWL Head Office;
- At the premises of any agent, Key Contractor or Subcontractor acting on behalf of BOWL;
- The BOWL Marine Coordination Centre at Wick;
- On-board the main installation vessel; and
- With the ECoW(s).

List of Abbreviations and Definitions

Term	Definition / Description
Application	The Application letters and Environmental Statement (ES) submitted to the Scottish Ministers by BOWL on 23rd April 2012 and Supplementary Environmental Information Statement (SEIS) submitted to the Scottish Ministers by BOWL on 29th May 2013.
ADD	Acoustic Deterrent Device.
BOWL	Beatrice Offshore Windfarm Limited (Company Number SC350248) and having its registered office at Inveralmond House, 200 Dunkeld Road, Perth, PH1 3AQ.
CLT	The BOWL Consent and Licensing Team.
CMS	Construction Method Statement as required for approval under Condition 11 of the S36 Consent and Condition 3.2.2.4 of the OfTW Marine Licence.
Commencement of the Wind Farm/OfTW	The date on which Construction begins on the site of the Wind Farm or the OfTW (as appropriate) in accordance with the S36 Consent or OfTW Marine Licence (as appropriate).
CoP	Construction Programme as required for approval under Condition 10 of the S36 Consent and Condition 3.2.2.3 of the OfTW Marine Licence.
CPUE	Catch Per Unit Effort.
Development	The Wind Farm and the OfTW.
DSFB	District Salmon Fisheries Board.
ECoW	Ecological Clerk of Works as required for approval under Condition 30 of the S36 Consent and Condition 3.2.2.12 of the OfTW Marine Licence.
EMP	Environmental Management Plan as required for approval under Condition 15 of the S36 Consent and Condition 3.2.1.2 of the OfTW Marine Licence.
EPS	European Protected Species.
ES	The Environmental Statement submitted to the Scottish Ministers by the Company on 23rd April 2012 as part of the Application as defined above.
ESRa	Evaluation of Systems for Ramming: Research group investigating noise mitigation systems for construction of pile-driven offshore wind farms.
FEED	Front End Engineering Design.
GI	Ground Investigation.
HLV	Heavy Lift Vessel.

Term	Definition / Description
IHLS	International Herring Larvae Surveys.
Inter-array cables	The AC electrical cables that connect the Wind Turbine Generators (WTGs) to the Offshore Transformer Modules (OTMs).
JNCC	Joint Nature Conservation Committee.
KC	Key Contractor(s) appointed for the individual work steams of Marine Installation, Transmission and WTGs.
Licencing Authority	The Scottish Ministers.
Marine Licences	The written consents granted by the Scottish Ministers under Section 20(1) of the Marine (Scotland) Act 2010, which were issued on 2nd September 2014.
MHWS	Mean High Water Spring.
MFRAG	Moray Firth Regional Advisory Group.
MFRAG-MM	Firth Regional Advisory Group Marine Mammal Sub-Group
MMMP	Marine Mammal Monitoring Programme.
MORL	Moray Offshore Renewables Limited.
MMO	Marine Mammal Observer.
MS	Marine Scotland.
MS - LOT	Marine Scotland Licensing Operations Team.
MSS	Marine Scotland Science.
OfTW	The Offshore Transmission Works. The OfTW includes the transmissions cable required to connect the Wind Farm to the Onshore Transmission Works (OnTW). This covers the OTMs and the cable route from the OTMs to the Mean High Water Springs (MHWS) at the landfall west of Portgordon on the Moray coast.
OnTW.	The Onshore Transmission Works from landfall, consisting of onshore buried export cables to the onshore substation and connection to the National Grid network.
ORJIP	Offshore Renewables Joint Industry Programme.
OSP	Offshore Substation Platform.
OTM	Offshore Transformer Module means an Alternating Current (AC) OSP which is a standalone modular unit that utilises the same substructure and foundation design as a wind turbine generator.
PAM	Passive Acoustic Monitoring.
Piling Mitigation Protocol	Protocol to mitigate injurious effects on marine mammals developed as an alternative to the JNCC (2010) guidelines.
PEMP	Project Environmental Monitoring Plan as required for approval under Condition 27 of the S36 consent and Condition 3.2.2.1 of the

Term	Definition / Description
	OfTW Marine Licence.
PIF	Pile Installation Frame.
PS	Piling Strategy as required for approval under Condition 12 of the S36 Consent and Condition 3.2.2.5 of the OfTW Marine Licence.
PTS	Permanent Threshold Shift.
S36 Consent	Consent granted by the Scottish Ministers under Section 36 of The Electricity Act 1989 to construct and operate the Beatrice Offshore Wind Farm electricity generating station, dated 19th March 2014.
SAC	Special Area of Conservation.
SEIS	The Supplementary Environmental Information Statement submitted to the Scottish Ministers by the Company on 29th May 2013 as part of the Application as defined above.
SHL	Seaway Heavy Lifting.
SMRU	Sea Mammal Research Unit.
SNCB	Statutory Nature Conservation Body.
SNH	Scottish Natural Heritage.
SPEAR model	Simple Propagation Estimator and Ranking model.
SRD	Soil Resistance to Driving.
Subcontractor	Subcontractor(s) to the Key Contractor(s).
TTS	Temporary Threshold Shift.
WDC	Whale and Dolphin Conservation.
Wind Farm	The offshore development as assessed in the ES including WTGs, their foundations, inter-array cabling and meteorological masts, excluding the OfTW.
WP	Work Package.
WTG	Wind Turbine Generator.

1 Introduction

1.1 Background

1.1.1 The Beatrice Offshore Wind Farm (the 'Wind Farm') received consent under Section 36 of the Electricity Act 1989 from the Scottish Ministers on 19th March 2014 (the S36 Consent) and was issued two marine licences from the Scottish Ministers for the Wind Farm and for the Offshore Transmission Works (OfTW) respectively, on 2nd September 2014 (the Marine Licences). The Wind Farm and the offshore transmission works are collectively referred to as the 'Development'.

1.2 Objectives of this Document

1.2.1 The S36 Consent and Marine Licences contain a variety of conditions that must be discharged through approval by the Scottish Ministers/Licensing Authority prior to the commencement of any offshore construction works. One such requirement is the approval of the proposed details of any foundation piling operations and associated environmental mitigation and monitoring measures through the preparation and approval of a **Piling Strategy (PS)**.

1.2.2 The relevant conditions setting out the requirement for a PS for approval, and which are to be discharged by this PS, are set out in full in Table 1.1. BOWL will be completing piling operations in constructing the Development, and therefore BOWL is required to comply with the consent conditions set out in Table 1.1.

Table 1.1 - Consent Conditions in the S36 Consent and Marine Licences for the Development.

Consent Reference	Condition Text	Section
Section 36 Condition 12	In the event that pile foundations are to be used, the Company [BOWL] must, no later than 6 months prior to the Commencement of the Development [Wind Farm], submit a PS, in writing, to the Scottish Ministers for their written approval. Such approval may only be granted following consultation by the Scottish Ministers with the Joint Nature Conservation Committee (JNCC), Scottish Natural Heritage (SNH) and any such other advisors as may be required at the discretion of the Scottish Ministers.	This document sets out the PS for approval by the Scottish Ministers.
	The Development [Wind Farm] must, at all times, be constructed in accordance with the approved PS (as updated and amended from time to time by the Company).	Section 2.0
	Updates or amendments to the PS must be approved, in writing, by the Scottish Ministers. Any updates or amendments made to the PS by the Company must be submitted, in writing, by the Company to the Scottish Ministers for their written approval.	Section 5.0.

Consent Reference	Condition Text	Section
	The PS must include: a) Full details of the proposed method and anticipated duration of pile-driving at all locations;	Section 6.3 and Section 7.4
	b) Details of soft-start pile-driving procedures and anticipated maximum pile-driving energy required at each pile location; and	Section 10.2 and Section 7.3
	c) Details of mitigation and monitoring to be employed during pile-driving, as agreed by the Scottish Ministers.	Section 10 and 11
	The PS must be in accordance with the Environmental Statement (ES) and reflect any surveys carried out after submission of the Application.	Appendix A
	The PS must demonstrate how the exposure to and / or the effects of underwater noise have been mitigated in respect of the following species: bottlenose dolphin; harbour seal; Atlantic salmon; cod; and herring.	Section 9 and 10
	The PS must, so far as is reasonably practicable, be consistent with the Environmental Management Plan (EMP), the Project Environmental Monitoring Plan (PEMP) and the Construction Method Statement (CMS). ***Reason: To mitigate the underwater noise impacts arising from pile-driving activity.***	Section 1.4
OfTW Marine Licence Condition 3.2.2.5	PS In the event that pile foundations are to be used, the Licensee must, no later than 6 months prior to the Commencement of the Works [OfTW], submit a PS, in writing, to the Licensing Authority for their written approval. Such approval may only be granted following consultation by the Licensing Authority with the JNCC, SNH and any such other advisors as may be required at the discretion of the Licensing Authority.	This document sets out the PS for approval by the Scottish Ministers.
	The PS must include: a). Full details of the proposed method and anticipated duration of pile-driving at all locations;	Section 6.3 and Section 7.4
	b). Details of soft-start pile-driving procedures and anticipated maximum pile-driving energy required at each pile location; and	Section 10.2 and Section 7.3
	c). Details of mitigation and monitoring to be employed during pile-driving, as agreed by the Licensing Authority.	Section 10 and 11
	The PS must be in accordance with the Application and reflect any surveys carried out after submission of the Application. The PS must demonstrate how the exposure to and / or the effects of underwater noise have been mitigated in respect of the following species: bottlenose dolphin; harbour seal; Atlantic salmon; cod; and herring.	Appendix A and Section 9 and section 10
	The PS must, so far as is reasonably practicable, be consistent	Section 1.4

Consent Reference	Condition Text	Section
	with the EMP, the PEMP and the CMS.	

1.2.3 The consent conditions (Table 1.1) requires that the PS demonstrate how the exposure to and/ or the effects of underwater noise have been mitigated in respect of the following species: bottlenose dolphin; harbour seal; Atlantic salmon; cod; and herring. In addition this PS has also considered how exposure to underwater noise will be mitigated for harbour porpoise.

1.2.4 The Wind Farm Marine Licence Consent Condition 3.2.1.6 requires the PS to consider the installation of pile foundations for a meteorological mast. However, Beatrice Offshore Windfarm Limited (BOWL) no longer intend to install a meteorological mast as part of the Wind Farm and, therefore, this Condition is not considered further in this document.

1.3 Scope of the Piling Strategy

1.3.1 This document seeks to satisfy, by approval, the consent conditions set out in Table 1.1. This PS demonstrates how BOWL have considered the species listed in the consent conditions (and additionally harbour porpoise) and how this has informed the PS.

1.3.2 The PS sets out the details of how piling will be phased throughout the construction of the Development, setting out the anticipated timing, location, duration and maximum piling energy for each turbine/ OTM location. It also provides a review of the refined project design envelope in so far as it relates to piling operations against the worst case impacts from piling assessed in the ES and SEIS and information on the mitigation measures which will be applied during the piling process and also the monitoring proposed in relation to piling noise.

1.3.3 This document contains the sections outlined in Table 1.2.

Table 1.2 - PS Document Structure

Section	Title	Overview
1	Introduction	Background to the consent requirements; brief outline of the scope and structure of this PS detailing how it will address the consent conditions and links to other relevant Consent Plans.
2	BOWL Statements of Compliance	Sets out the BOWL statements of compliance in relation to this PS consent conditions and the ES and the SEIS and also summarises those relevant pre-construction surveys required by other consent conditions that have, for fish, informed this PS.

Section	Title	Overview
3	Communication Plans	Provides an overview of the roles and responsibilities and lines of communication for key individuals involved in the piling operations and delivery of mitigation.
4	Consultation	Provides a summary of the consultation undertaken with Marine Scotland Licencing Operations Team (MS-LOT) and their statutory advisors with regard to this PS.
5	Updates and Amendments to this PS	Sets out the change management process for amendments to this PS in the event of any significant new information related to the piling methods.
6	Wind Farm Construction Overview	Sets out the Wind Farm layout, overview of the sequence of events during construction, the proposed piling method in detail, and the construction piling programme.
7	Anticipated Maximum Piling Energies and Durations	Sets out a description of geotechnical information and pile-driveability assessment undertaken and results showing anticipated hammer energies and anticipated durations of piling across the Wind Farm.
8	Environmental Sensitivities	Outlines the key sensitivities for bottlenose dolphin, harbour seal, harbour porpoise, Atlantic salmon, herring and cod.
9	Reduction of the Design Envelope in Comparison to the ES/SEIS	Provides a quantification of the reduction in the design envelope and disturbance to key species by comparing the worst case scenario presented in the ES and SEIS to the Wind Farm layout and piling process now proposed.
10	Mitigation	Provides a summary of the Piling Mitigation Protocol to minimise the risk of instantaneous death and injury to marine mammal receptors and the mitigation requirements related to fish species.
11	Monitoring	Summary of the ongoing monitoring that will inform this PS, including testing that mitigation devices (ADDs) are performing as required, monitoring of noise emitted by piling, and mitigation monitoring.
12	Licences and Legal Requirements	Provides a summary of additional licences which may be required for the piling activity.
13	Reporting and PS Auditing	Sets out the PS related reporting and auditing requirements.

1.3.4 In developing this PS BOWL have consulted with the Licencing Authority and relevant stakeholders (see Section 4 of this PS). Further information on reporting the results from monitoring and mitigation from this PS is set out in Sections 11, 12, and 13.

1.4 Linkage to Other Consent Plans

1.4.1 Ultimately this PS will form part of a suite of approved documents that will provide the framework for the construction process – namely the other consent plans required under the S36 Consent and the OfTW Marine Licence. Consent Condition 12 of the S36 Consent and Condition 3.2.2.5 of the OfTW Marine Licence requires this PS to be, so far as is reasonably practicable, consistent with a number of other specifically named consent plans, namely (in the order listed in the consent condition):

- The EMP (required under Condition 15 of the S36 Consent and Condition 3.2.1.2 of the OfTW Marine Licence);
- The PEMP (required under Condition 27 of the S36 consent and Condition 3.2.1.1 of the OfTW Marine Licence); and
- The CMS (required under Condition 11 of the S36 Consent and Condition 3.2.2.4 of the OfTW Marine Licence).

1.4.2 The other consent plans named in the PS consent condition have a link to the PS in so far as they either provide additional details on the construction methodology (for example the CMS) and/or provide details on the control of construction to mitigate, manage and/or monitor potential environmental impacts (for example the EMP and PEMP).

1.4.3 The linkages between this PS and the other named consent plans is set out in Table 1.3.

Table 1.3 - Piling Strategy - Consistency and links to other named consent plans.

Other Named Consent Plan	Consistency with, and linkage to, this PS
EMP	In accordance with the S36 Consent Condition 15 and the OfTW Marine Licence Consent Condition 3.2.1.2, an EMP will be produced to cover the construction and operation of the Development. This will provide the overarching environmental management framework setting out procedures to be applied during these phases. In addition to the mitigation detailed within this PS, the relevant parts of the EMP will be adhered to during the construction of the Development.
PEMP	In accordance with the S36 Consent Condition 27 and the OfTW Marine Licence Consent Condition 3.2.1.1, a PEMP will be produced to cover the pre-construction, construction (if appropriate) and post-construction monitoring surveys, including surveys for marine mammals and which involve participation in the Marine Mammal Monitoring Programme (MMMP).
CMS	In accordance with the S36 Consent Condition 11 and the OfTW Marine Licence Consent Condition 3.2.2.4 a CMS will be produced to describe the construction of the Development. This will set out the construction procedures and good working practices for installing the Development and will be in accordance with the construction methods assessed in the ES and SEIS.

2 BOWL Statement of Compliance

2.1 Statements of Compliance

2.1.1 The CMS (required under Condition 11 of the S36 consent and Condition 3.2.2.4 of the OfTW Marine Licence) sets out in full the BOWL statement of compliance relating to construction of the Development (excluding the export cable), and incorporates foundation piling operations.

2.1.2 The key points to note from the CMS with regards to this PS are as follows:

- BOWL in undertaking the construction of the Development will ensure compliance with this PS as approved by the Scottish Ministers;
- BOWL will require compliance with the approved PS (and all other relevant, approved Consent Plans) by the Key Contractors through conditions of contract and will monitor compliance through an appropriate auditing process;
- BOWL will ensure that a Project organogram is in place and that the roles and responsibilities of all named personnel are clear and that clear project management procedures are in place for all aspects of the construction of the development, including those related to this PS; and
- BOWL will require that all construction personnel attend required project inductions including, but not limited to, matters related to this PS.

2.2 ES and SEIS

2.2.1 Condition 12 of the S36 Consent and condition 3.2.2.5 of the OfTW Marine License (Table 1.1) require that:

the PS must be in accordance with the Environmental Statement (ES) and reflect any surveys carried out after submission.

2.2.2 The sections below set out the commitments made in the ES (BOWL, 2012a) and SEIS (BOWL, 2013) in relation to matters relevant to this PS. This section also summarises the post-consent monitoring surveys that have been completed and are relevant to and considered within this PS.

ES and SEIS Commitments

2.2.3 The commitments made in the ES and SEIS with respect to bottlenose dolphin, harbour seal, harbour porpoise, herring, cod and Atlantic salmon are a key component of this PS. A summary of relevant commitments outlined in the ES/SEIS is presented in Appendix A, together with confirmation on the current status of the commitment (including where that commitment has been refined for the approval of the Scottish Ministers following post consent consultations with MS-LOT, MSS and the SNCBs) and cross references to where the implementation of each is set out in this PS.

2.2.4 The focus of this PS, based on the conclusions of the ES/ SEIS and the commitments made, is mitigation against the following effects on the species considered:

- Harbour seal and bottlenose dolphin (and subsequently harbour porpoise): instantaneous death and injury during piling.
- Cod and Herring: disturbance to spawning behaviour from piling.
- Atlantic salmon: disturbance to migrating smolts and adults from piling, and barrier effects between the Wind Farm and the Caithness coastline.

2.2.5 Section 8 of this PS sets out the description of the sensitivity for each of these species whilst Section 10 sets out the proposed mitigation approach in each case and Section 11 sets out proposed monitoring where relevant.

Post Consent Surveys

2.2.6 Post consent surveys for marine mammals and fish have been completed in line with the requirements of the various, relevant S36 and Marine License conditions. Although these conditions will be discharged independently from the conditions set out in Table 1.1 (by approval of individual survey reports and the PEMP), the surveys have provided further information following the award of the Project consents, and, for cod and herring, they have informed the mitigation requirements set out in Section 10.3 of this PS.

2.2.7 The key consent conditions requiring monitoring or surveys, and a brief overview of these surveys with regards to the receptors considered in this PS, are set out below. Section 8 (Environmental Sensitivities) provides an overview of the findings of these surveys where relevant.

Marine mammals

2.2.8 S36 Consent condition 27b and OfTW Marine License condition 3.2.1.1b (Project Environmental Monitoring Programme (PEMP)) require BOWL to participate in surveys to be carried out in relation to marine mammals as set out in the Marine Mammal Monitoring Programme (MMMP).

2.2.9 BOWL, in conjunction with Moray Offshore Renewables Limited (MORL) and the University of Aberdeen, have collaborated in the development of a regional pre-construction MMMP which has been agreed with Marine Scotland, statutory bodies and stakeholders (in the MFRAG-MM Subgroup). The pre-construction surveys set out in the MMMP are ongoing and the results continue to be reported. Further information on the MMMPs will be provided in the PEMP.

Cod

2.2.10 S36 Conditions 27 (PEMP) and 35 (pre and post-construction surveys for cod), require BOWL to complete pre and post-construction cod spawning surveys. BOWL have completed the pre-construction surveys which were undertaken in February and March

2014. The full results of these surveys are presented in a cod spawning survey technical report (BOWL 2014b), and are summarised in Section 8 (Environmental Sensitivities) and the resulting proposals in relation to mitigation are set out in Section 10.3 (Mitigation).

2.2.11 As noted in Section 4 (Table 4.1) MSS has confirmed that the cod surveys completed in February and March 2014 meet the requirements of the pre-construction elements of the relevant consent conditions.

Herring

2.2.12 S36 Consent Conditions 27 (PEMP) and 34 (pre-construction herring spawning surveys), require BOWL to complete pre-construction herring spawning surveys every year during the months of August and September and up until the last August and September prior to the commencement of the construction of the Development.

2.2.13 BOWL completed the first pre-construction surveys in August and September 2014. The full results of the surveys are presented in the herring larval survey technical report (BOWL, 2014a), and are summarised in Section 8 (Environmental Sensitivities) and the resulting proposals in relation to mitigation are set out in Section 10.3 (Mitigation).

2.2.14 As noted in Section 4 (Table 4.1) MSS has confirmed that they agree with the survey design and the approach to the identification of herring larvae and that the results are sensible with sufficient data to give confidence in the results. MSS has also confirmed that the results strongly suggest that herring spawning had taken place to the north of the Wind Farm off Orkney and Shetland, and not in the vicinity of the Wind Farm.

Atlantic salmon

2.2.15 S36 Conditions 27 (PEMP) and 31 (participation in the 'Scottish Atlantic Salmon, Sea trout and European Eel Monitoring Strategy' (Moray Firth)), and OfTW Marine License conditions 3.2.1.1a1 (PEMP) and 3.2.1.3 (participation in the 'Scottish Atlantic Salmon, Sea trout and European Eel Monitoring Strategy' (Moray Firth)), require BOWL to carry out monitoring for diadromous fish (with regards to this PS this applies to Atlantic salmon) on a regional scale. BOWL has developed a monitoring strategy for Atlantic salmon smolts in consultation with MSS. The details of this monitoring will be set out in the PEMP.

3 Communication Plans

3.1 Roles and Responsibilities

3.1.1 The following sections detail the key roles and responsibilities for implementing the various elements of this PS and details how communications between the responsible parties involved in piling operations will be managed during construction.

3.1.2 BOWL's preferred Key Contractor (KC) for the completion of foundation installation is Seaway Heavy Lifting (SHL). The responsibility for ensuring the day to day implementation of this PS will lie with SHL and the ADD operator.

3.1.3 Further information on broader organisational responsibilities and interfaces (and the 'chain of command') in relation to broader environmental management issues is set out for approval in the EMP.

BOWL Senior Project Manager

3.1.4 The BOWL Senior Project Manager will ensure that sufficient resources and processes are in place to deliver/comply with this PS. They will ensure that provision is made for PS issues/marine mammal mitigation to form part of construction progress meetings and project inductions.

3.1.5 They will be responsible for ensuring that contractual obligations are established for contractors in relation to this PS. They will require that all construction personnel and contractors assist and support the Ecological Clerk of Works (ECoW; see paragraph 3.1.14 onwards) where required for the delivery of this PS.

BOWL Package Manager (Marine Installations)

3.1.6 The Package Managers have similar responsibilities to the Senior Project Manager, but in relation to their specific packages of work. In this case, the piling operations fall under the marine installations package.

3.1.7 The Package Managers have the following responsibilities in relation to the PS:

- Responsible for ensuring that sufficient resources and processes are in place across the marine installations package to deliver/comply with the PS;
- Ensuring that provision is made for matters relating to the delivery of the PS form part of construction progress meetings and Project inductions;
- Ensuring that all construction personnel and contractors assist and support the ADD operator and the ECoW where required, in delivering the PS and monitoring or auditing compliance with the PS;
- Establishing contractual obligations for Key Contractors and Subcontractors in relation to PS;
- Reporting to the BOWL Senior Project Manager on matters related to the PS;

and

- Where necessary, addressing Key Contractor and Subcontractor non-compliance in relation to the PS.

BOWL Consents and Licensing Team

3.1.8 Monitoring ongoing compliance with this PS is ultimately the responsibility of the BOWL Consents and Licensing Team (CLT), supported by the ECoW and the ADD operator.

3.1.9 Responsibilities for the BOWL CLT in relation to this PS include:

- Primary contact for MS-LOT / the Licensing Authority, statutory bodies and stakeholders (excluding the responsibilities taken by the ECoW) and liaison with MORL;
- Managing ECoW reporting on compliance with consent conditions to MS-LOT / the Licensing Authority;
- Ensuring post consent surveys are completed on time, and in line with consent conditions;
- Managing the process of obtaining new consents where necessary or monitoring consent applications made by Key Contractors;
- Attendance at Project meetings;
- Reviewing contractor documentation (e.g., method statements, risk assessments etc.) to ensure compliance with this PS; and
- Submit the final ‘Piling Report’ to MS-LOT.

Key Contractor: Seaway Heavy Lifting

3.1.10 BOWL is intending to contract SHL to complete the foundation installation operations (as well as the broader package of marine installations).

3.1.11 SHL have provided input from an offshore installation perspective into this PS, and will be required to ensure implementation of and compliance with this PS during construction and installation of the Development and for appropriate liaison with the ADD operator and the ECoW.

SHL Offshore Manager and Vessel Personnel

3.1.12 The Offshore Manager, employed by SHL, will be based on the heavy lift vessel (HLV) used to install the pile foundations. In consultation with the vessel’s master, the Offshore Manager will be in charge of all operations on the main deck, including piling operations. The Offshore Manager will be responsible for ensuring that piling operations are undertaken in a controlled, safe and efficient manner in line with this PS and as per pre-planned operative guidelines and for appropriate liaison with the ADD operator.

3.1.13 The ADD operator will be assisted by SHL vessel personnel on the HLV for the deployment of the ADD.

Ecological Clerk of Works

3.1.14 The ECoW is responsible for providing quality assurance of the Piling Strategy, as required under the S36 Consent and Marine Licences, and monitoring, and providing advice to BOWL on compliance with this PS.

3.1.15 The ECoW is responsible for communicating the requirements of this PS, monitoring implementation of this PS and reporting on ongoing compliance with this PS to MS-LOT / the Licensing Authority throughout the construction phase.

3.1.16 The ECoW will work with the ADD Operators and more widely with the BOWL package managers and SHL, attending relevant project meetings, to ensure the requirements of this PS are understood, carry out site inductions with regard to this PS, and ensure that this PS is implemented. The ECoW will also be responsible for reporting on compliance to MS-LOT / the Licensing Authority.

3.1.17 In the event that the Development is progressed at the same time as the adjacent MORL development, BOWL would explore with MORL whether the respective ECoWs could hold progress meetings to discuss site specific issues and share learning across projects.

ADD Operator

3.1.18 Two ADD Operators, appointed by BOWL, will be responsible for deployment, maintenance and operation of the ADD, including spare equipment, in relation to all piling activities. Two ADD Operators are required to cover shifts since the piling is scheduled to take place over a 24 hour working period. During each shift, the ADD Operator on shift will be supported by SHL vessel personnel, who can be trained *in situ*. The ADD Operators will be required to liaise with the SHL Offshore Manager in order to confirm timing for piling operations and therefore when the ADD needs to be deployed. The ADD Operators will be in direct contact with the SHL Offshore Manager via radio. Any problems with the ADD will be communicated immediately to the SHL Offshore Manager and a decision can then be made as to the most appropriate course of action. Further details are provided in the ADD Deployment Procedure set out in Appendix C.

3.1.19 The ADD Operators will test the functioning of the ADD device using a separately deployed hydrophone (also known as a PAM system). The hydrophone will remain switched on from the testing of the ADD and until cessation of the soft start piling at each pile location. The ADD Operators will also record any marine mammal observations prior to and during ADD deployment.

3.1.20 The ADD Operators will be suitably trained to JNCC standards as Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM) operators, with an appropriate level of field experience. Further details on training and the role of the

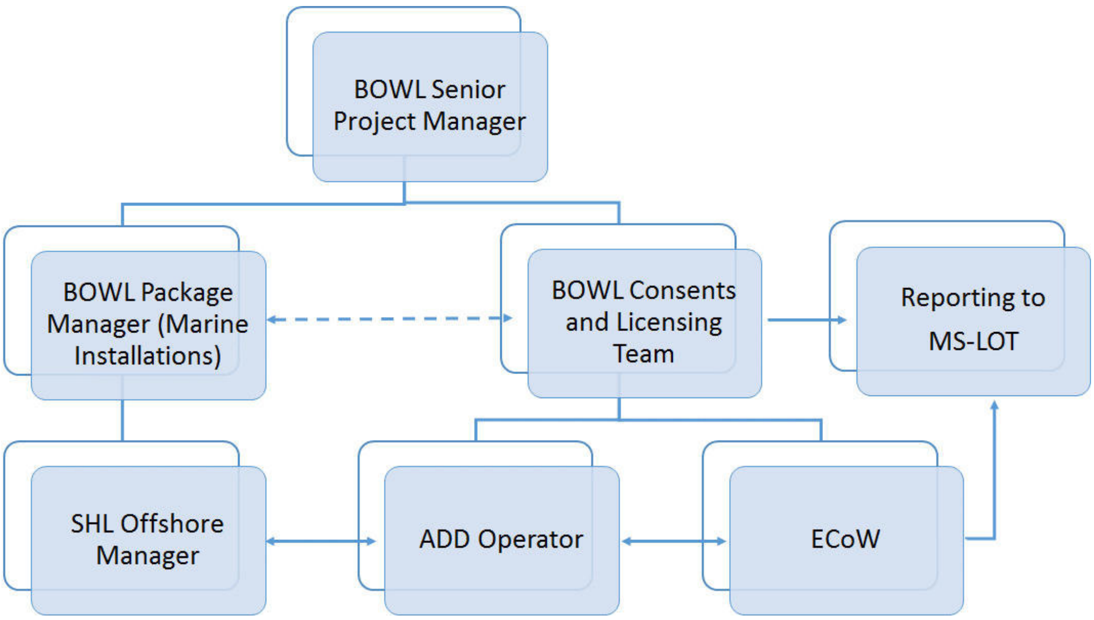
ADD Operators, and a full list of tasks are provided in the ADD Deployment Protocol in Appendix C. BOWL will inform MS-LOT / the Licensing Authority and the Statutory Nature Conservation Bodies (SNCBs) on the appointment of the ADD Operators.

3.1.21 The ADD Operators will be responsible for collating, managing and reporting on data regarding the piling operations in order to verify that the correct mitigation procedures have been carried out. Regular reporting will be provided to the BOWL ECoW. Section 13 sets out the details of reporting against this PS. Further information on ADD deployment is set out in Appendix C.

3.2 Organisational Chart

3.2.1 An organisational chart of the identified roles (Section 3.1) for the implementation of this PS during construction is provided in Figure 3.1, this shows the key interfaces and lines of communication during the piling operations.

Figure 3.1 - PS roles and lines of communication



4 Post Consent Consultation

4.1.1 The consultation undertaken with MS-LOT and their statutory advisors SNH and JNCC as well as Marine Scotland Science (MSS) (and also Whale and Dolphin Conservation (WDC)) with regard to this PS and the proposed mitigation and monitoring proposals is summarised in Table 4.1.

4.1.2 S36 Consent Condition 28 and Marine Licence (OfTW) Condition 3.2.2.18 require that BOWL participate in the Moray Firth Regional Advisory Group (MFRAG). During the post-consent consultation period, The MFRAG Marine Mammal Subgroup (MFRAG-MM) was officially formed on 1st April 2015 to advise the Scottish Ministers on research, monitoring and mitigation programmes. The MFRAG-MM Subgroup, chaired by MSS, comprises the marine mammal consultees listed above together with BOWL and MORL and their advisors. Professor Paul Thompson acts as a special advisor on marine mammals to both BOWL and MORL, and sits on the MFRAG-MM Subgroup. Prior to the MFRAG-MM Subgroup being officially formed, consultation was undertaken with the Subgroup members as individual organisations, to discuss and agree the monitoring and mitigation strategy for marine mammals.

4.1.3 MSS is the key advisory body with regard to cod and herring. Discussions with regard to the pre-construction surveys completed by BOWL for cod have also been had in the MFRAG.

4.1.4 MSS, SNH and other relevant bodies are the relevant consultees regarding Atlantic salmon. Discussions related to Atlantic salmon will also be undertaken through the MFRAG forum.

Table 4.1 - Summary of Key Consultations Undertaken to Date on the PS

Date	Consultee	Purpose of Consultation and Issues Discussed	Outcome
Marine Mammals			
02/04/14	MS-LOT	Issued letter to MS-LOT containing the final draft of the pre-construction marine mammal monitoring programme (MMMP).	MS-LOT email received 10 October 2014 confirming approval of the pre-construction MMMP.
05/03/15	MS-LOT, MSS	Meeting to agree an approach to the discharge of conditions relating to the PS. Preliminary discussion on alternative mitigation procedure (including the use of ADDs) to that presented in the JNCC guidelines was initiated. BOWL and MORL set out justifications for an alternative with engineering input provided by both developers.	MS-LOT and MSS agreed to consider an alternative, provided suitable evidence was presented to statutory advisors (SNH and JNCC) in order to present a case for use of ADDs.

Date	Consultee	Purpose of Consultation and Issues Discussed	Outcome
26/03/15	MFRAG-MM Subgroup	Draft construction MMMP was issued to the MFRAG-MM Subgroup for review and comment.	Draft construction MMMP was presented and discussed at MFRAG-MM Subgroup meeting 30/03/15.
30/03/15	MFRAG-MM Subgroup	Outline of BOWL and MORL's approach to the PS. Presentations on pile-driving sequencing and technical challenges and on BOWL/MORL's approach to the Piling Mitigation Protocol as an alternative to JNCC guidelines, as well as an update on additional monitoring proposed within the construction MMMP.	The MFRAG-MM Subgroup requested that BOWL comply as far as possible with the JNCC guidelines but agreed that the BOWL/MORL Piling Mitigation Protocol could be considered with further consultation in the MFRAG-MM. It was agreed that a risk assessment be undertaken by BOWL and MORL to demonstrate the differences in impact on marine mammals as a result of the marked reduction in the project design envelope from that assessed in the BOWL ES.
24/04/15	SNH, JNCC	Comments received from SNH and JNCC on the draft construction MMMP 24 April 2015.	Professor Paul Thompson incorporated these comments and the construction MMMP was issued to the MFRAG-MM Subgroup members in advance of the MFRAG-MM Subgroup meeting on 19/06/15.
07/05/15	MSS, SNH, JNCC	Further to the MFRAG-MM Subgroup request that a risk assessment be produced (meeting 30 March) a risk assessment was produced by Professor Paul Thompson and issued to statutory stakeholders. The risk assessment demonstrates the differences in effects on marine mammals as a result of the marked reduction in the project design envelope from that assessed in the BOWL ES.	The risk assessment was discussed with statutory stakeholders on 08/05/15.
08/05/15	MSS, SNH, JNCC	Professor Paul Thompson met with statutory consultees to discuss the proposed framework to support the adoption of the Piling Mitigation Protocol.	Consultees requested that BOWL and MORL develop and submit a written procedure to illustrate how this mitigation could be put into practice.
11/05/15	MFRAG Main Group meeting	BOWL and MORL provided a brief update on the Piling Mitigation Protocol.	It was agreed that a document outlining the guiding principles of mitigation during piling be prepared for discussion at the next

Date	Consultee	Purpose of Consultation and Issues Discussed	Outcome
			MFRAG-MM meeting in mid-June, setting out how mitigation would be applied in various construction scenarios, as a basis for further discussions on the potential use of ADDs.
01/06/15	MFRAG Main Group	The draft 'Protocol for mitigating the risk of instantaneous death or injury to marine mammals during piling at the BOWL and MORL Wind Farms' was submitted to the MFRAG-MM. The Protocol set out the proposed mitigation at the BOWL and MORL wind farms using ADDs and piling soft starts.	BOWL/ MORL requested that the MFRAG-MM Subgroup review the document and provide comments.
19/06/15	MFRAG-MM Subgroup meeting	The proposed Piling Mitigation Protocol was discussed at the meeting, part of which sets out proposed monitoring of responses of harbour porpoise and harbour seal to ADD and soft starts.	The Piling Mitigation Protocol was discussed as requested by the MFRAG-MM Subgroup. The principles of the Piling Mitigation Protocol were agreed. It was also agreed that the principles of construction monitoring should be provided and discussed in further detail with the MFRAG-MM Subgroup.
29/06/15	SNH	Consultation between SNH and Professor Paul Thompson to discuss options for site specific noise monitoring to measure the noise emitted from the piling operations.	Agreement was reached between BOWL and SNH on the objectives and possible outline of noise monitoring to measure the noise emitted from piling.
07/07/15	SNH/JNCC	Meeting with SNH/JNCC to discuss BOWL's project specific approach to the PS.	Agreement was reached between BOWL and SNH/JNCC on key details to be provided in the PS, subsequently incorporated into this document.
31/07/15	MFRAG-MM Subgroup	Issued the revised Piling Mitigation Protocol to the MFRAG-MM Subgroup members.	The protocol was updated to incorporate comments from the MFRAG-MM Subgroup meeting on 19/06/15.
07/08/15	SNH	Received written response to the Piling Mitigation Protocol issued via MFRAG.	Amendments incorporated into the Piling Mitigation Protocol in Appendix D of this document.
28/08/15	SNH	Meeting with Paul Thompson and Nathan Merchant (CEFAS) regarding noise modelling approach for estimating instantaneous injury zone. injury zone	Propagation modelling revised and injury zone changed from 68 m to 60 m following recommendations from SNH injury zone

Date	Consultee	Purpose of Consultation and Issues Discussed	Outcome
09/09/15	JNCC	Received written response to the Piling Mitigation Protocol issued via MFRAG.	Amendments incorporated into the Piling Mitigation protocol in Appendix D of this document.
09/09/15	MS/JNCC/ SNH/WDC	Received written responses from the consultees on the draft Piling Strategy consent plan.	Updates incorporated into this document, including the addition of an ADD Deployment Protocol (Appendix C).
Fish			
19/12/14	MS-LOT	BOWL issued the pre-construction herring spawning survey report to MSS and MS-LOT for approval (BOWL, 2014a).	Documents issued for approval and to inform discussions on this PS.
13/03/15	MS-LOT	BOWL issued the cod pre-construction cod spawning survey report to MSS and MS-LOT for approval (re-submission of the original document following agreement on how to calculate Catch Per Unit Effort (CPUE) to assess the importance of survey locations for spawning cod) (BOWL, 2014b).	Documents issued for approval and to inform discussions on this PS.
07/01/15	MSS	Letter from MSS providing their response to the herring survey technical report.	MSS agreed with the survey design and the approach for the identification of herring larvae and confirmed the results are sensible with sufficient data to give confidence in the results. MSS confirmed the results suggest that spawning had taken place to the north of the Wind Farm off Orkney and Shetland.
19/01/15	MS-LOT MSS and SNH	Meeting with MS-LOT, MSS and SNH to discuss various topics including the results from the herring survey completed in August and September 2014, and the implications of the survey in respect of piling.	MSS re-stated agreement with the survey design, approach for identification of larvae and that the results give reasonable confidence and re-confirmed the results strongly suggest that spawning had taken place to the north of the Wind Farm.
11/03/15	MS-LOT	Letter from BOWL requesting MS-LOT provide written confirmation that the pre-consent baseline cod survey conditions can be discharged.	MS-LOT confirmed that the cod surveys completed in February and March 2014 meet the relevant consent requirements with official sign-off to be provided following approval in the MFRAG main

Date	Consultee	Purpose of Consultation and Issues Discussed	Outcome
			group meeting.
11/05/15	MFRAG Main Group meeting	BOWL provided an overview of the pre-construction cod survey methods and results to the Group.	The surveys and results were approved in the Group. MS-LOT agreed to issue written confirmation that the cod surveys discharge the pre-construction elements of S36 Consent conditions 35 (cod surveys), and 27 (PEMP) (cod monitoring).
03/07/15	MSS	Meeting with MSS regarding certain studies required by consent conditions, including cod spawning and herring larval surveys, and BOWLs monitoring proposal for Atlantic salmon smolts. The cod and herring spawning results were discussed in the context of the PS. BOWL highlighted that while it is considered unlikely, they may need to pile-drive at some stage during the period between December 2017 and March 2018 which may coincide with cod spawning activity in February and March 2018. Flexibility to undertake pile driving activities is required should the 2017 piling programme not be completed on schedule due to delays caused by potential engineering and commercial constraints.	Confirmed that BOWL's 2014 (Year 1) herring spawning survey report had been accepted by MSS and MS-LOT. BOWL queried whether it could be assumed that mitigation for spawning herring during piling operations would not be required should the results from the 2015 herring surveys resemble those of the 2014 surveys, i.e. that herring spawn off Orkney and Shetland and therefore outside the area of potential noise impact from the Wind Farm. MSS confirmed that this assumption is accurate, and that if this is the case mitigation would not be required. For cod, MSS stated that if piling were to be undertaken during the period of February and March 2018 then mitigation would be required in relation to cod spawning based on results from the 2014 survey. Proposed mitigation for these circumstances is set out in section 10.3 below. In relation to Atlantic Salmon, MSS confirmed that piling mitigation for migratory fish, based on the impact reduction from the ES worst case to the Piling Strategy final design, would reduce effects on salmon including barrier effects. As such, MSS noted that it would be fair to assume that mitigation for salmon would not be required.

5 Updates and Amendments to this PS

5.1.1 This PS sets out the proposed methods for piling at the Development and procedures to mitigate the effects of piling on the sensitive marine mammal and fish species identified in the relevant consent conditions, as well as harbour porpoise. The S36 consent condition recognises that updates or amendments to this PS may be required, stating that:

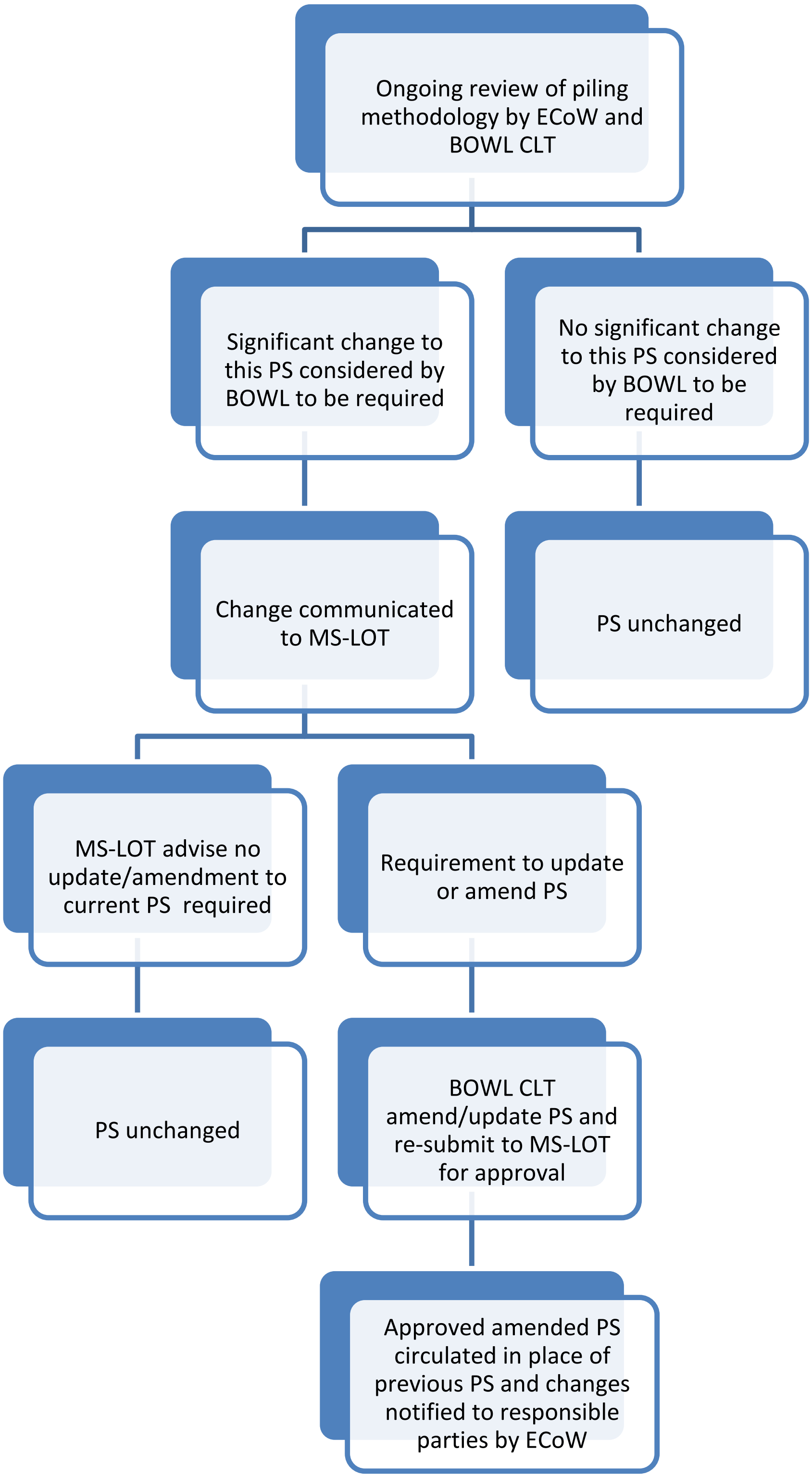
The Development must at all times, be constructed in accordance with the approved PS (as updated and amended from time to time by the Company). Updates or amendments to the PS must be approved, in writing, by the Scottish Ministers. Any updates or amendments made to the PS by the Company must be submitted, in writing, by the Company to the Scottish Ministers for their written approval.

5.1.2 Should it be necessary to update this PS in the light of any significant new information related to the piling operations, BOWL propose to use the change management process set out in Figure 5.1: in identifying such information; in communicating such change to the Scottish Ministers; in re-drafting this PS; in seeking further approval for the necessary amendments or updates; and in disseminating the approved changes/amendments to responsible parties.

5.1.3 Furthermore, any significant changes to the Piling Mitigation Protocol (Appendix D) will be agreed with Marine Scotland in consultation with MFRAG and following the change management process set out in Figure 5.1.

5.1.4 Similarly, significant amendments or updates to the detailed ADD Deployment Protocol (Appendix C) (for example a change to the proposed ADD device) will be communicated and agreed with Marine Scotland after consultation with the relevant statutory consultees and following the process in Figure 5.1.

Figure 5-1 - PS change management procedure



6 Wind Farm Construction Overview

6.1 Wind Farm Layout

6.1.1 The Beatrice Offshore Wind Farm will consist of 84 wind turbines and two OTMs. The Wind Farm layout is shown in Figure 6.1. Note that the layout includes two spare wind turbine/OTM locations that would only be used in the event that difficult ground conditions were encountered and micro-siting at the preferred positon was not possible (these are shown in blue on Figure 6.1).

6.1.2 The wind turbines will be installed in an array format. Inter-array cables will connect six wind turbines in a string and each string will be connected back to the OTMs, which will be centrally located.

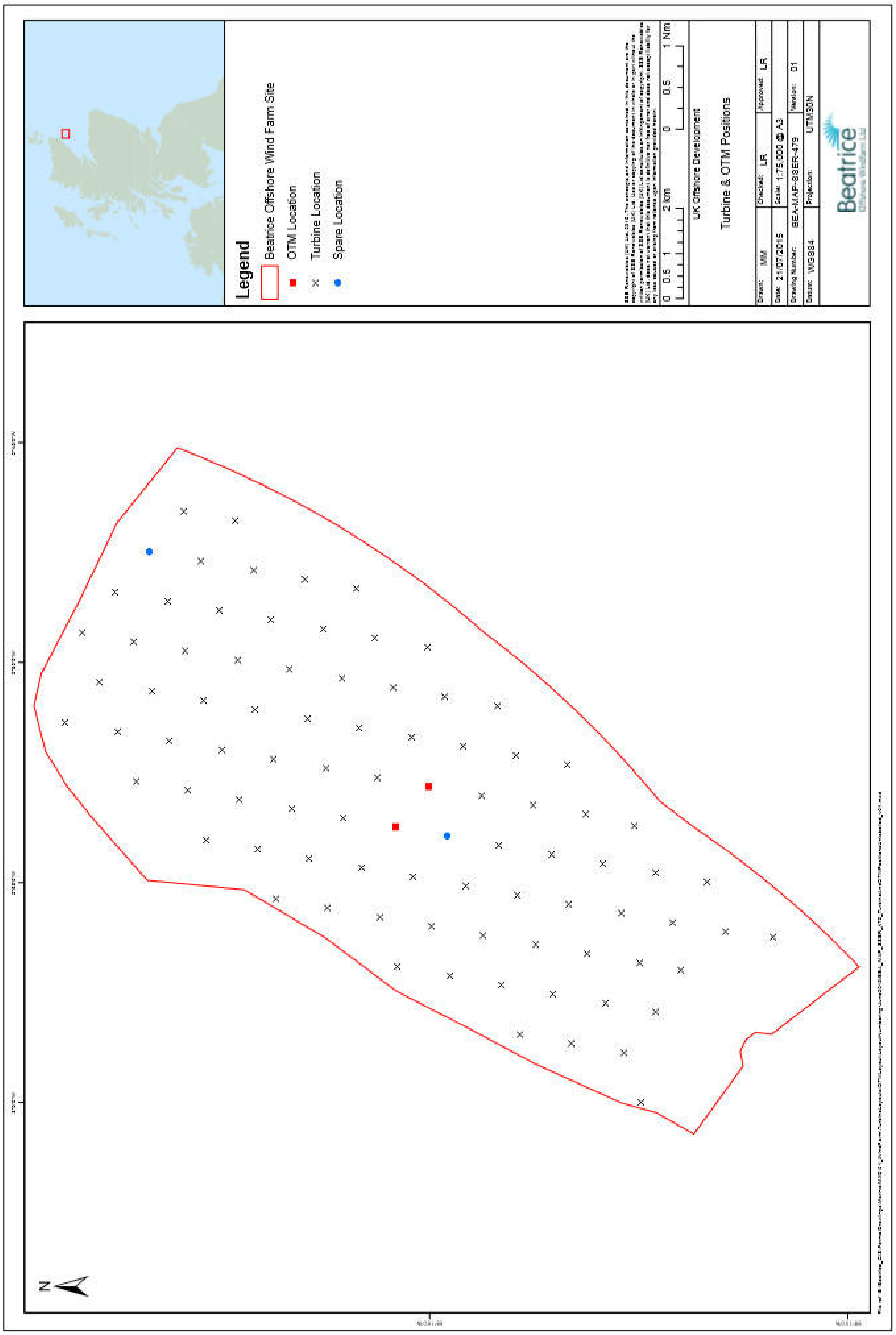


Figure 6-1 - Final layout of wind turbines and OTMs at the Wind Farm site

6.2 Wind Farm Construction Sequence

6.2.1 Both wind turbines and OTMs will be installed on jacket support structures, each requiring four piled foundations to be installed. The total number of pile foundations to be installed across the site is 344 (86 structures x 4). Installation of pile foundations will be the first activity to be completed in the installation of wind turbines and OTMs.

6.2.2 The CMS for the Wind Farm (required under Condition 11 of the S36 Consent and Condition 3.2.2.4 of the OfTW Marine Licence) describes the wind turbine and OTM installation process, including the piling process, and should be referred to for full details of the overall wind farm and OTM construction process.

6.2.3 An overview of the installation processes is provided in Figure 6.2 (wind turbine support structures (piled foundations and jacket substructures) and turbines) and Figure 6.3 (OTMs) below. Further details on the approach to piling are provided in Section 6.3.

Figure 6.2 - Overview of the Wind Turbine installation process

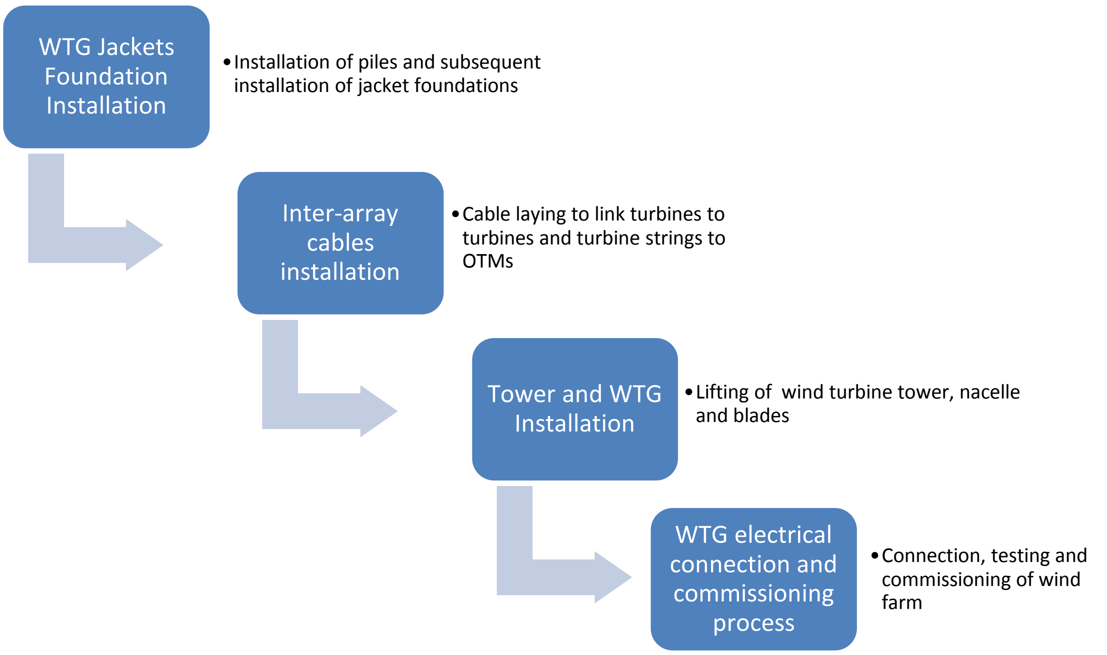
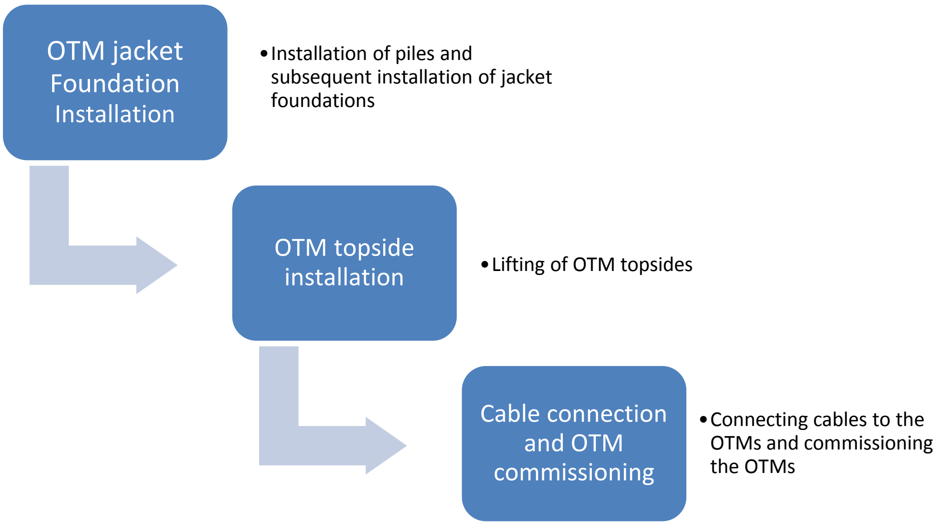


Figure 6.3 - Overview of the OTM installation process



6.3 Proposed Piling Method

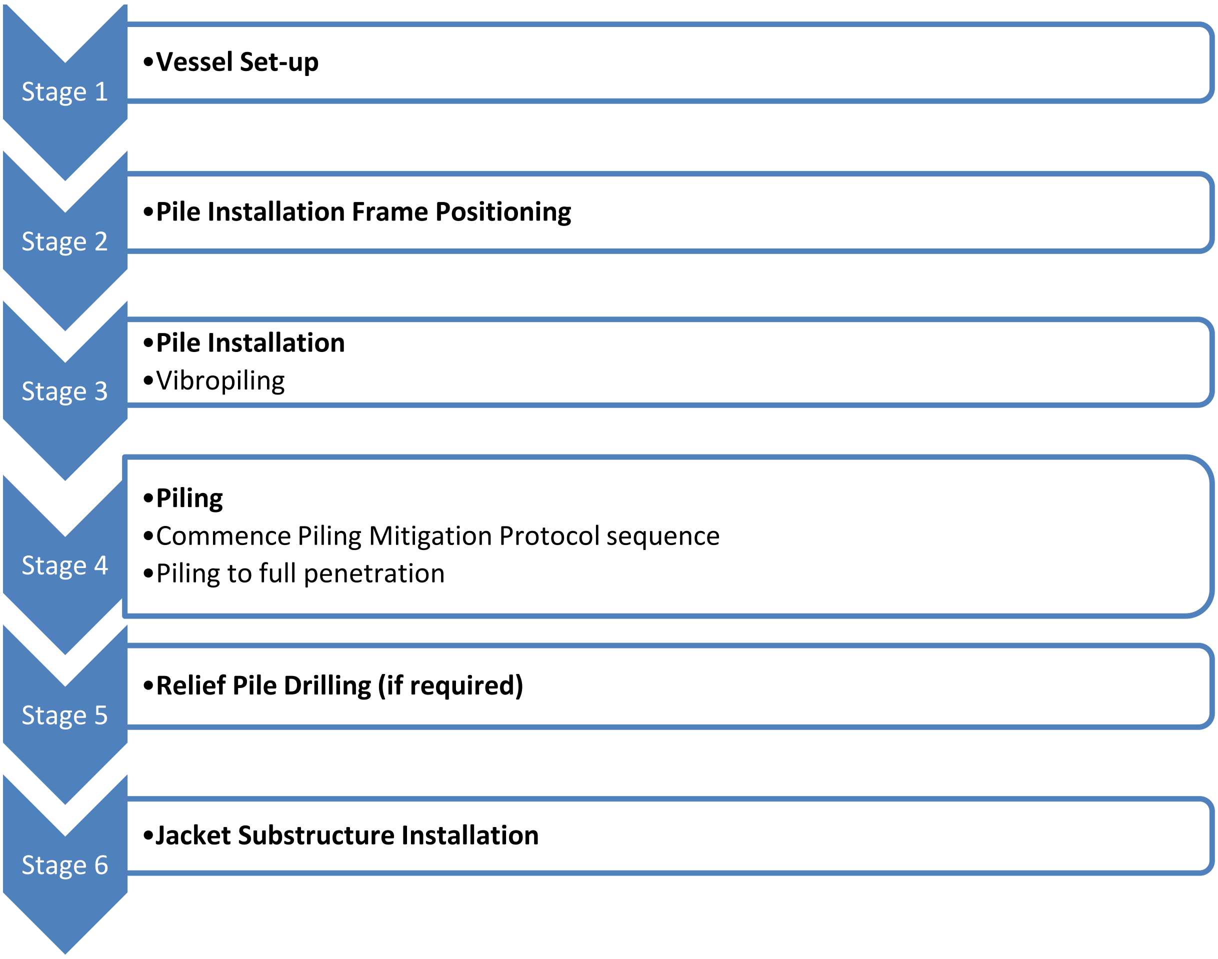
6.3.1 The S36 Consent Condition 12a and Marine Licence Condition 3.2.2.5a (OfTW) set out the following requirement for this PS to include:

a. full details of the proposed method and anticipated duration of piling at all locations.

6.3.2 This section sets out the proposed method of piling operations (piling duration is set out separately under Section 7.4). The piling process describes the full process from pile set up through to the piling stage and finishing with jacket substructure installation (Figure 6.4). Greater detail on each of the stages in the process (Stage 1 – 6) is provided in the subsequent sections.

6.3.3 Notably, the crucial stage, in terms of potential effects on sensitive receptors and for which mitigation is proposed, is the piling process (Stage 4 in Figure 6.4). The piling operation is anticipated to be the same at each location and for both wind turbine and OTM foundations.

Figure 6.4 – Pile foundation (and jacket substructure) Installation sequence



Stage 1 – Vessel Set Up

6.3.4 Pile foundations will be installed by a Heavy Lift Vessel (HLV) which will arrive at the proposed foundation installation location and will be positioned in readiness for the foundation installation works. Piling operations are expected to be conducted from a single piling vessel.

6.3.5 Depending on which HLV is used this would involve either the placing of an anchor spread using a dedicated anchor handling tug or positioning by use of a dynamic positioning (DP) system.

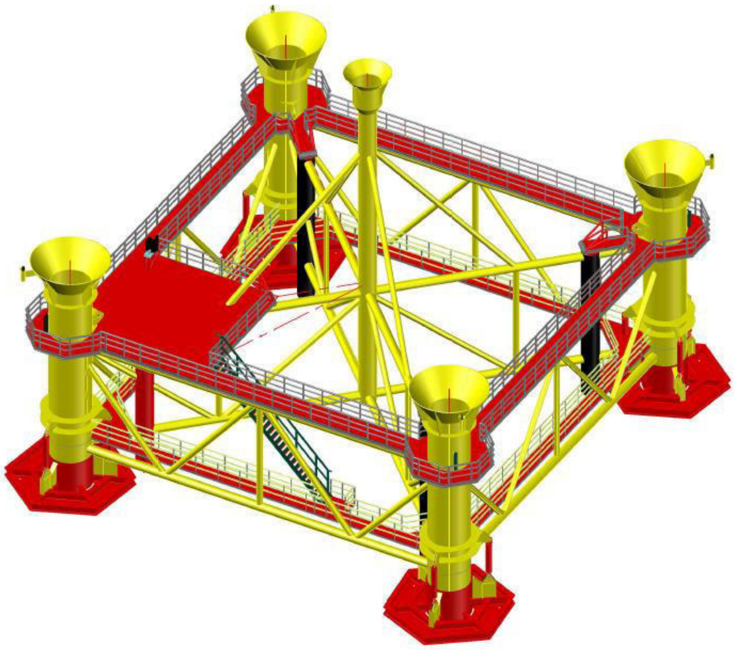
6.3.6 The approximate duration of vessel set-up will be 5.5 hours.

Stage 2 – Pile Installation Frame Positioning

6.3.7 Pile foundations will be installed by the use of a Pile Installation Frame (PIF), an example of which is shown in Figure 6.5. Pile installation tolerances will be achieved through the use of a hydraulically operated PIF with sufficient travel to accommodate the worst case seabed slopes to ensure the piles are installed correctly.

6.3.8 The PIF will have a footprint of approximately 32 m x 32 m and will weigh circa 400 tonnes.

Figure 6.5 - Example of a hydraulically operated pile installation frame (PIF)



6.3.9 The PIF will be lifted from the HLV and lowered to the seabed in positon ready for the piling operations and levelled hydraulically to take into account seabed slope.

6.3.10 The approximate duration of pile installation frame positioning will be 4 hours.

Stage 3 – Pile Installation

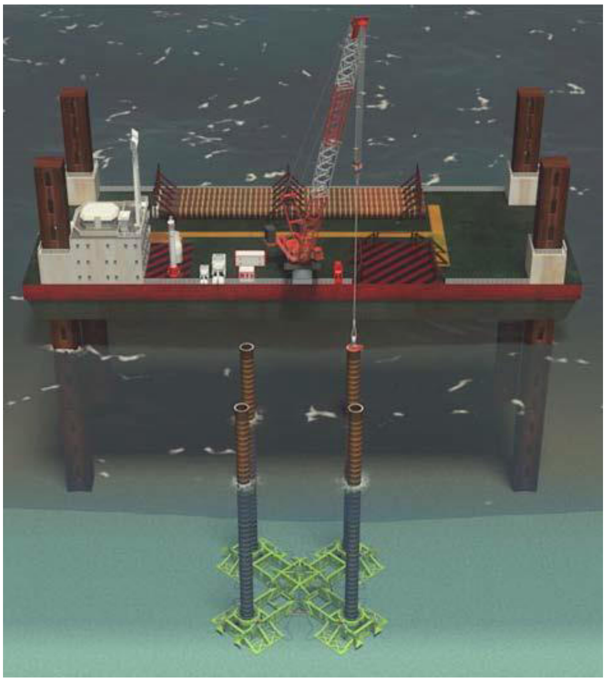
6.3.11 The pile foundations will be delivered to the HLV by cargo barge directly from the manufacturing site. The cargo barge will be moored alongside the HLV and the four piles will each be lifted and transferred to the deck of the HLV. The cargo barge will then be unmoored and will depart.

6.3.12 Each of the four piles will then be lifted, upended, lowered into the PIF and vibrated (vibro-piled) in readiness for the piling operation (see Figure 6.6a).

6.3.13 Vibropiling is a technique used to make the pile oscillate at a low frequency of about 20Hz. Having been lifted into the PIF, each pile will be vibro-piled to a nominal penetration or until refusal, whichever occurs first. This process continues until all four piles are settled in the PIF (see Figure 6.6b). The purpose of the vibropiling will be to settle the piles into the PIF in advance of percussive piling.

6.3.14 The approximate duration of pile installation at each location is 7 hours. The approximate duration of vibropiling will be up to 2 hours at each location.

Figure 6.6 - a) Pile being up-ended ready for deployment and b) being deployed into the PIF



Stage 4 – Piling

<u>*Piling Mitigation Protocol*</u>

6.3.15 The piling hammer will be lifted on to the top of the first pile in the PIF. The approximate duration of setting up the piling hammer on the first pile will be 2 hours.

6.3.16 Prior to commencing piling the Piling Mitigation Protocol described in Section 10.2 (and set out in full in Appendix D) will be implemented. This will include the deployment of the ADD and a soft start piling procedure.

6.3.17 The approximate duration of mitigation depends on the duration of any breaks (see Section 10.2 for further information on breaks). ADDs may also be deployed for the durations described in the Piling Mitigation Protocol concurrently with setting up the piling hammer.

Piling to Full Penetration

6.3.18 Following completion of the mitigation described above (and set out in Section 10.2), the piling operators will gradually increase the hammer energy applied until the pile is penetrating the seabed at the target rate of approximately 1 cm to 2.5 cm per hammer strike (see Figure 6.7 for pile hammer installing a pile). If this target rate is reached with a lower than anticipated hammer energy, the hammer energy is unlikely to be increased further. Final penetration depth is reached when the pile foundations stick up between 2m and 6m above the seabed.

6.3.19 Once the first pile in the PIF has been fully installed, the hammer will be repositioned to commence piling at the next pile in the PIF. The mitigation implemented prior to commencing this second piling event will depend on the duration of the break between piling each pile in the PIF as set out in the Piling Mitigation Protocol described in Section 10.2 (and set out in full in Appendix C).

6.3.20 The anticipated duration for re-positioning the hammer to commence piling at the next pile in the PIF will be 10 minutes to 1 hour. For the four piles hammer re-positioning may therefore take up to 3 hours in total.

6.3.21 The anticipated duration of piling to full penetration depth (including the mitigation period) at each wind turbine or OTM location ranges between 5.4 to 12.7 hours.

6.3.22 Once all four of the piles in the PIF have been pile-driven to the required depth pile metrology is performed (measurements to determine pile position and depth is satisfactory). The duration for performing pile metrology is 1 hour.

6.3.23 The PIF will then be recovered back to the deck of the HLV and the HLV will be readied for transit to the next foundation location. Recovery of the PIF will take approximately 2.5 hours.

Figure 6.7 - Pile hammer installing a pile

Stage 5 – Relief Drilling (if required)

6.3.24 Where pile depth cannot be achieved due to ground conditions, the piling hammer would be withdrawn and a reverse circulation drilling unit would be inserted until the desired penetration depth is reached whereupon the piling is resumed to full depth.[1]. The mitigation procedure for planned or unplanned breaks would be followed prior to re-commencing piling (Figure 10.1, Section 10.2).

Stage 6 – Jacket Substructure Installation

6.3.25 Once piling is complete at one or a number of the wind turbine or OTM locations, the HLV will prepare for the installation of the jacket substructures into the pre-installed pile foundations. Jacket substructures will either be installed immediately after the four piles at a wind turbine or OTM location have been installed, or pile foundations will be installed at a number of locations before the HLV returns at a later date to each location to complete the jacket substructure installation. Further details on the jacket substructure installation process are set out in the CMS.

[1] The potential impacts of drilling were assessed in the Beatrice Offshore Wind Farm ES (using the subsea noise SPEAR model) and the noise levels generated were found to be considerably lower than that from piling (Section 12.2.7.8 in BOWL, 2012a).

Summary of the Duration of Piling Operations

6.3.26 Table 6.1 below summarises the anticipated durations for each stage of the piling operations sequence described in the preceding sections (no allowance is made for weather down time or other breaks in foundation installation).

Table 6.1 – Summary of the duration of each stage of the foundation installation process (durations are per wind turbine and OTM location)

Event	Approximate Duration
Vessel Set Up	5.5 hours
PIF Positioning	4 hours
Pile Installation (including vibropiling)	7 hours Vibropiling: up to 2 hours
Piling (including the time required to implement the mitigation set out in the Piling Mitigation Protocol described in Section 10.2 and piling to desired penetration depth). (Excludes any time required for relief drilling or micro-siting)	Hammer set-up: 2 hours Piling to full penetration (including mitigation soft start): 5.4 to 12.7 hours Moving piling hammer between piles: up to 3 hours
Perform Pile Level Measurements (Pile Metrology)	1 hour
Recovery of the PIF	2.5 hours
Total duration of piling operations at each wind turbine/ OTM location	Approximately 32 - 40 hours

6.4 Foundation Installation Programme

6.4.1 Details on the timing of the overall construction programme for the Beatrice offshore Wind Farm are provided in the Construction Programme (CoP) submitted for approval, as required under the S36 Consent Condition 10 and the OfTW Marine Licence Condition 3.2.2.3.

6.4.2 Foundation installation operations (including piling) will take place over the following periods:

- April to November 2017; and
- April to September 2018.

6.4.3 Foundation installation in the period December 2017 to March 2018 is possible but unlikely. BOWL requires the flexibility to pile in these months in the event that delays caused by engineering and supply constraints in the first period do not impact significantly on the second 'season' of foundation installation in 2018. As BOWL cannot completely rule out the requirement to complete piling operations during these months, the development of mitigation measures set out in Section 10 have assumed the piling may also occur in the December 2017 to March 2018 period.

6.4.4 The programme set out in the CoP provides for contingency for weather downtime. Other scenarios that may cause delay include the unexpected occurrence of boulders which may require relief drilling operations, the requirement to implement unexpected breaks, or delayed delivery of pile foundations. Further information on planned and unplanned breaks is provided in the following section.

Planned and Unplanned Breaks

6.4.5 Planned and unplanned breaks are common occurrences during piling operations. Planned breaks are factored into programme planning and can generally be avoided during piling. However unplanned breaks can potentially have a significant impact on the programme for foundation installation. Potential causes of unplanned breaks include, but are not limited to:

- Deteriorating weather conditions leading to piling operations no longer being possible. Piling operations are particularly sensitive to wave height and high winds;
- Equipment/mechanical breakdown such as a fault in the piling hammer. As a worst case this can lead to the HLV having to return to port to change the hammer. Alternatively, such breakdowns may be only minor in nature and result in only minor delays; and
- Unexpected pile refusal with the need to relief drill.

6.4.6 Examples of planned breaks are:

- Hammer repositioning to commence piling at a pile in the PIF after completing piling of a pile in the same PIF. This is expected to take approximately 10 minutes to 1 hour; and
- Changing of a hammer due to known wear and tear. This would occur after a complete foundation installation and could take several days during which time activities would be completed such as jacket installation. When piling resumes, the Piling Mitigation Protocol described in section 10.2 and in Appendix D will be adhered to.

6.4.7 One potential consequence of a break in piling is pile 'setup'. Pile setup is the term used to describe an increase in soil resistance following a piling break due to the settlement and consolidation of the soils around the pile. Under this scenario, the energy required to displace the pile on re-commencement of piling will be likely to be greater than the continuous driving energy normally required for the same pile. A break in piling can therefore result in an increase in the hammer energy required to install the pile over that necessary for continuous piling.

Piling Operations Sequence across the Wind Farm

6.4.8 Water depth has been a significant factor in determining the sequence of wind turbine and OTM foundation installation across the Wind Farm site. The water depth ranges from approximately 38m in the south to 55m in the north. With this depth range there is a requirement for varying jacket heights to ensure the height of the structures above sea surface level is consistent across the site.

6.4.9 To ensure the most efficient pile foundation and jacket substructure installation, the Wind Farm site has been split into five clusters on the basis of depth range, with the shallowest water sites represented by cluster 1 and the deepest water sites by cluster 5 as shown in Figure 6.8.

6.4.10 It is anticipated that installation of pile foundations and jackets at the cluster 1 and cluster 2 wind turbine and OTM locations, will be completed in the first piling ‘season’, i.e. in April to November 2017. Installation of support structures at the cluster 3 to 5 wind turbine locations is anticipated to be completed in the second piling ‘season’, i.e. in April to September 2018. Piling from December 2017 to March 2018 is possible but unlikely as described above.

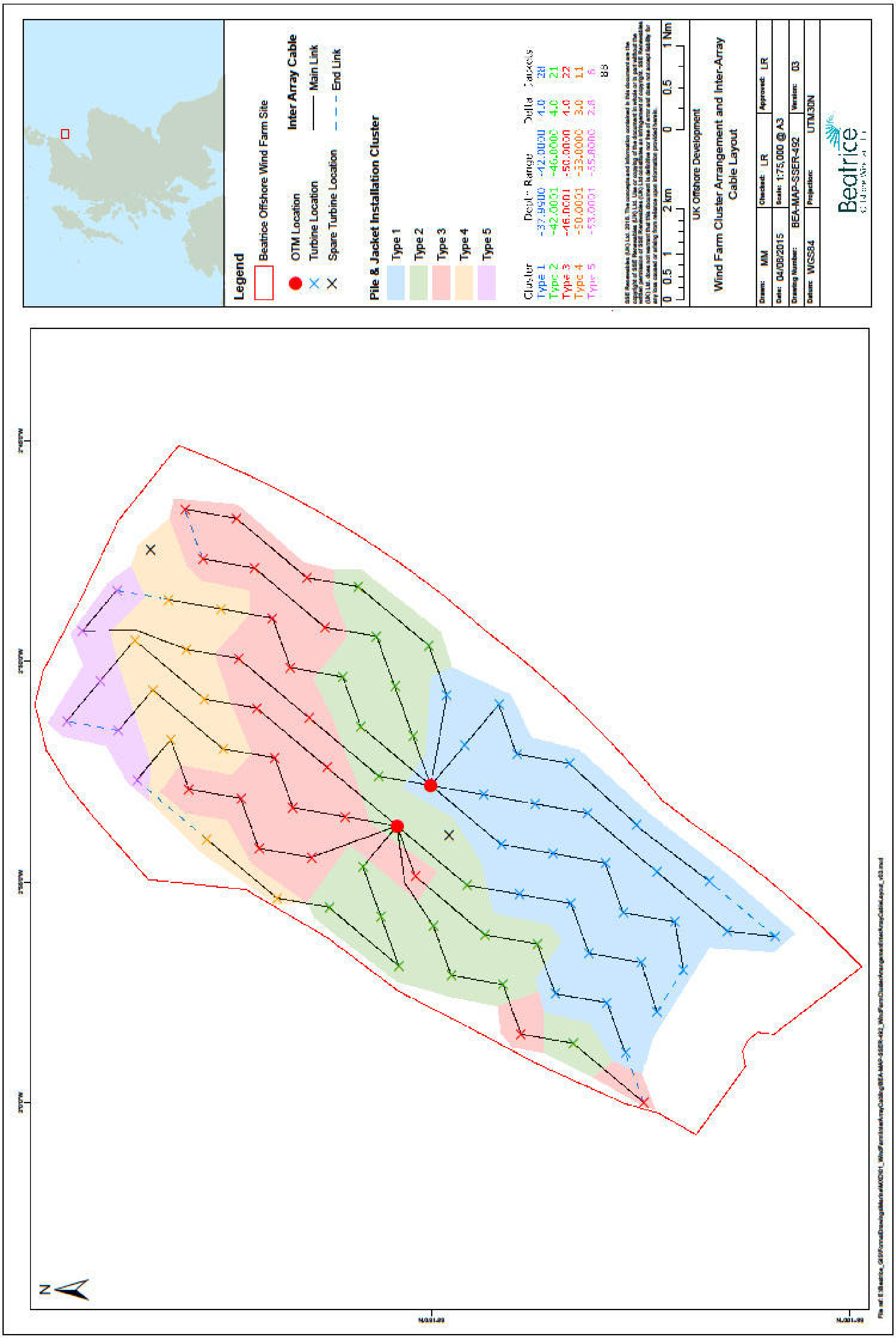


Figure 6.8 - Clusters of WTG/OTMs based on depth range for the Wind Farm site

7 Anticipated Maximum Piling Energies and Durations

7.1 Introduction

7.1.1 The S36 Consent Condition 12b and Marine Licence Condition 3.2.2.5 a and b (OfTW) set out the requirement for this PS to include:

b. Details of soft-start piling procedures and anticipated maximum piling energy required at each pile location;

7.1.2 The sections below set out how BOWL have arrived at the anticipated maximum piling energies (Section 7.3) and durations (Section 7.4) across the Wind Farm site. Details of the soft-start piling procedures are contained in Section 10.2.

7.2 Geotechnical Information

7.2.1 Ground investigations (GI) involving the collection of borehole samples to provide information on the subsurface geology across the 84 wind turbine, 2 OTM and 2 spare locations (88 locations in total) have been completed by BOWL in stages, to inform various engineering design requirements including the pile driveability across the Wind Farm site.

7.2.2 In 2013 BOWL collected borehole samples from 27 of the 88 locations (Fugro, 2014). Figure 7.1 shows the spread of the 27borehole locations across the Wind Farm site. The detailed geological information derived from these boreholes is available and has been used to derive estimates of the anticipated maximum hammer energies and piling durations set out in Sections 7.3 and 7.4 below.

7.2.3 In July 2015 BOWL completed the collection of borehole samples for the remaining 61 turbine/ OTM locations. Analysis of the data collected from the borehole samples will be available in Quarter 2, 2016, and will be used to complete the pre-construction pile driveability modelling to inform the detailed installation programme.

7.2.4 The geological properties at the 27 locations sampled were analysed and a ground model (referred to as the 'GI model') was produced to describe the geological properties at the borehole locations. Soil strength (or resistance), an important factor in estimating the likely piling energy, was identified and was classified as low (sand, gravelly sand or sand and clay); moderate (dense sand and clay and boulders) or high (cemented layers of bedrock with dense sand and clay).

7.2.5 The GI model was used to inform an interim pile driveability assessment based on information on pile parameters available at the time of completion (loads required for a 6 MW wind turbine and a pile diameter of 1.8 m). Since the interim pile driveability assessment was undertaken, BOWL have progressed the Front End Engineering Design (FEED) significantly, and modifications to the engineering design have been made. Modifications include slightly increased loads that the pile foundations are required to withstand due to the decision to install the Siemens 7 MW turbines, and a subsequent increase in pile diameter to 2.2 m. These increased modifications remain within the consented envelope and the assessments made in the ES and SEIS. These factors change the pile driveability of the piles (and therefore the hammer energies and durations required to install the piles).

7.2.6 Consequently, a subsample of 12 of the 27 borehole locations were re-analysed with the updated design parameters to determine the differences in pile-driveability. The results from the 12 subsamples were then used to benchmark the piling resistance (measured as Soil Resistance to Driving (SRD)) across the remaining 15 borehole locations. Piling resistance was then extrapolated across all 88 wind turbine/OTM/spare locations to determine the anticipated maximum piling energies and durations required.

7.2.7 Further detail on the method of calculating and benchmarking the piling energies and durations is provided in Appendix B.

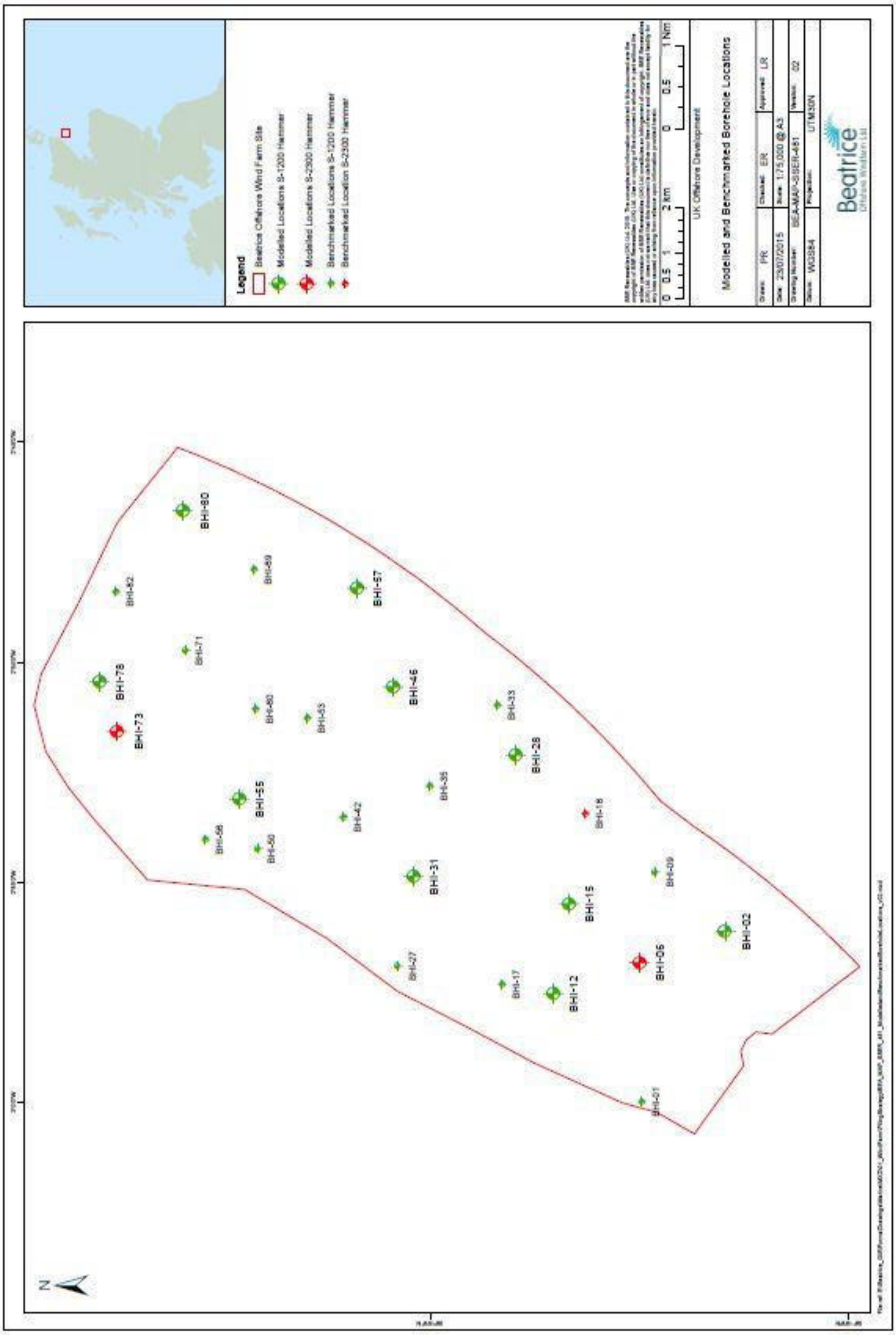


Figure 7.1 - Location of the 27 borehole samples taken during the first GI campaign

7.3 Anticipated Hammer Energies (kJ)

7.3.1 The maximum Hammer Energy that could be employed at each of the foundation locations and to install each of the pin pile foundations will be up to 2300kJ as permitted by the S36 and Marine Licence consents.

7.3.2 However, the geotechnical information set out in section 7.2 above has been used to determine more realistic, anticipated maximum hammer energies that are likely to be employed across the area based on a geotechnical analysis of the 27 boreholes described in Section 7.2. The estimated maximum piling hammer sizes (maximum energy in kJ) required at the 27 borehole locations are shown in Table 7.1.

7.3.3 The borehole locations shown in bold are the locations that were re-analysed in the updated pile driveability assessment, the borehole locations not shown in bold are the benchmarked locations. The locations of these boreholes are shown in Figure 7.1, which also shows the estimated maximum hammer energies required for pile installation at each location. At most locations it is predicted that pile installation will be achieved using a 1,200 kJ hammer, with currently only sites 6, 18 and 73 potentially requiring a larger hammer energy of up to 2300kJ.

Table 7.1 – Estimated hammer sizes (energy kJ), blow count and piling durations for each of the 27 borehole locations

Borehole location	SRD (kN)	Estimated piling hammer size (kJ)	Estimated cumulative blow count	Estimated pile driving duration (mins)
1	**56.79**	**S-1200**	**3685**	**123**
2	50.00	S-1200	3746	125
6	80.00	S-2300	5433	181
9	**56.79**	**S-1200**	**5244**	**175**
12	68.00	S-1200	5667	189
15	39.00	S-1200	3418	114
17	**53.24**	**S-1200**	**4462**	**149**
18	**101.15**	**S-2300**	**5834**	**194**
27	**53.24**	**S-1200**	**5209**	**174**
28	62.00	S-1200	4231	141
31	50.00	S-1200	4381	146
33	**49.69**	**S-1200**	**4110**	**137**
35	**44.36**	**S-1200**	**2432**	**81**
42	**63.88**	**S-1200**	**4847**	**162**
46	61.00	S-1200	5421	181
50	**31.94**	**S-1200**	**3623**	**121**

Borehole location	SRD (kN)	Estimated piling hammer size (kJ)	Estimated cumulative blow count	Estimated pile driving duration (mins)
53	**49.69**	**S-1200**	**4363**	**145**
55	60.00	S-1200	4563	152
56	**62.11**	**S-1200**	**3962**	**132**
57	63.00	S-1200	3580	119
60	**53.24**	**S-1200**	**3026**	**101**
69	**53.24**	**S-1200**	**3201**	**107**
71	**47.91**	**S-1200**	**3642**	**121**
73	82.00	S-2300	4726	158
78	55.00	S-1200	3422	114
80	71.00	S-1200	3988	133
82	**62.11**	**S-1200**	**2932**	**98**

7.3.4 Table 7.2 shows a summary of the estimated hammer energies required across the whole Wind Farm site, extrapolated from the data shown in Table 7.1.

Table 7.2 - Estimated piling hammer energy and number of locations at which each hammer size is likely to be required.

Hammer Size	SRD Range (kN)	Number of borehole locations within this range
S-1200	<71	72
S-1800	71-80	11
S-2300	>80	5

7.3.5 Based on the analysis provided by the design engineers, the preferred marine installation contractor, SHL, who are likely to be undertaking the foundation installation, have confirmed that these hammer energies should be considered reasonable estimates of the hammer energies required during piling activities at each location.

7.3.6 Whilst the estimates set out in Tables 7.1 and 7.2 are considered reasonable, there remains the risk of encountering unexpected ground conditions, such as boulders, at some of the wind turbine and OTM foundation locations. Therefore, it is possible that higher hammer energies may be required (but will ultimately be limited to the maximum consented 2300 kJ hammer energy) at a greater number of locations than is suggested in Table 7.2. That said, the target pile penetration rate is 1 cm to 2.5 cm per hammer strike; if this is achieved at a lower than anticipated piling/hammer energy, it is unlikely that the piling energy would be increased further. It is therefore equally possible that some pile foundations may be installed at lower than the estimated piling energies set out in Table 7.2.

7.4 Anticipated Duration of Piling

7.4.1 The S36 Consent Condition 12a and Marine Licence Condition 3.2.2.5a (OfTW) set out the requirement for this PS to include:

a. Full details of the proposed method and anticipated duration of piling at all locations;

7.4.2 This section describes the estimated minimum, maximum and mean piling durations (per pile and for four piles per support structure) for the wind turbine and OTM locations.

7.4.3 The anticipated duration of piling at the 27 borehole locations was calculated from the pile-driveability assessments described in Section 7.2 above with estimated piling durations at each of the 27 borehole locations provided in Table 7.1. The 27 locations are considered representative of likely piling durations across the Wind Farm site.

7.4.4 Calculations of piling duration include provision for the mitigation soft start described in Section 10.2 and are based on a blow count frequency of 30 blows per minute (this is derived from SHL's extensive experience in completing similar piling operations). No provision is made for the vibropiling operations in the calculations, which would be likely to decrease the duration of total piling per pile and therefore the values presented are considered conservative in this respect.

7.4.5 The estimated maximum, minimum and mean durations of piling per pile, including soft start, are as follows:

Maximum duration (per pile)	**Minimum duration (per pile)**	**Mean duration (per pile):**
194 minutes (3.2 hours)	81 minutes (1.6 hours)	140 minutes (2.3 hours)

7.4.6 For each wind turbine or OTM location the estimated total piling time required to install all four piles, including soft start, are as follows:

Maximum duration (per location)	**Minimum duration (per location)**	**Mean duration (per location):**
776 minutes	324 minutes	560 minutes

Maximum duration (per location)	Minimum duration (per location)	Mean duration (per location):
(12.7 hours)	(5.4 hours)	(9.3 hours)

7.4.7 Applying these estimates per wind turbine or OTM location, the estimated total time spent piling (including the mitigation soft start) across all of the 84 wind turbine and 2 OTMs (and including piling at the 2 spare locations as a worst case) ranges from approximately 19.8 to 47.4 days (2.8 weeks to 6.8 weeks).

7.4.8 As a proportion of the programmed foundation installation periods (i.e. April to November 2017 and April to September 2018 (427 days or 61 weeks)), the minimum and maximum estimated piling period equates to approximately 4.6% to 11.2% respectively.

8 Environmental Sensitivities

8.1 Introduction

8.1.1 This section sets out the key sensitivities (relating to noise emissions from foundation piling) for bottlenose dolphin, harbour seal, harbour porpoise, Atlantic salmon, cod and herring (based on the data set out in the ES / SEIS). In addition, this section summarises the results obtained from the pre-construction surveys and monitoring completed to date, in line with the requirements of S36 Consent Condition 12 and the Marine Licence Condition 3.2.2.5:

The PS must be in accordance with the Application and reflect any surveys carried out after submission of the Application.

8.1.2 These pre-construction surveys have in some cases informed or confirmed the temporal and spatial sensitivities of the above species. This information is intended to provide further context to the proposed species specific mitigation set out in Section 10.

8.2 Marine mammals

8.2.1 In the ES and SEIS bottlenose dolphin, harbour seal and harbour porpoise were identified as being potentially sensitive to the subsea noise arising from the piling of foundations.

8.2.2 The potential impacts of noise emitted from piling on these marine mammal populations that were considered in the ES and SEIS as part of the EIA process were:

(1) Instantaneous death or injury (physical or auditory) from single noise pulses at close range;

(2) Auditory damage from accumulated noise doses; and

(3) Behavioural disturbance.

8.2.3 In respect of (2) and (3) above, the assessments set out in the ES and SEIS concluded that there would be no significant long term effects on the populations of the three key marine mammal species; the Habitats Regulations Assessment (HRA) concluded that there would be no effect on the long term conservation status of bottlenose dolphin and harbour seal (BOWL, 2012a and 2012b); mitigation of disturbance effects are not therefore considered in this PS.

8.2.4 In respect of (1) above, BOWL set outs its commitment to mitigation in the ES and SEIS. The proposed Piling Mitigation Protocol is set out in Section 10.2 of this PS.

Bottlenose Dolphin

8.2.5 Bottlenose dolphins are most likely to be encountered around the southern coastal areas and inner reaches of the Moray Firth, generally in waters less than 25 m deep. Areas of particular importance include Spey Bay, Chanonry Point and Sutors (Hastie *et al.,* 2004; Cheney *et al*., 2012). Counts of bottlenose dolphin around the coast decrease during the winter, but whether this is a reflection of movement into offshore waters or a caveat of winter sampling effectiveness is unknown (Wilson *et al*. 1997). It is likely that their seasonal distribution will relate to the distribution of key prey items, however, there is limited understanding of the broader diet of bottlenose dolphin in European waters and how the prey stocks vary in space and time.

8.2.6 The interim results of the BOWL pre-construction MMMP have shown that, at key sites within the Moray Firth SAC and along the southern Moray Firth coast, bottlenose dolphin occurrence tends to be highest from May to August (Graham *et al*., 2015). These summer peaks of bottlenose dolphin in inshore areas could, without further analysis suggest that the population may be more sensitive to disturbance in the summer. However, this conclusion may only be valid in those specific inshore areas should a seasonal influx of dolphins coincide with high levels of local disturbance in those same areas.

8.2.7 Available data suggests that the likelihood of bottlenose dolphin being encountered around the Development site is low (BOWL, 2012a; Thompson *et al.,* 2015). Given the uncertainties regarding seasonal distribution in offshore waters and sensitivities, for the purposes of this PS, bottlenose dolphin is considered to be equally sensitive in all months of the year.

Harbour Seal

8.2.8 Harbour seal occur year-round in the Moray Firth and use haul-out sites to rest between foraging trips, during the pupping and breeding season in June/July and to moult in August/September (Bailey and Thompson, 2011). Key haul-outs occur within the inner Moray Firth, and those closest to the Development area are found in the Dornoch Firth, Loch Fleet, Dunrobin, Sputie Burn and Lothmore. The nearest major breeding site to the Wind Farm is Loch Fleet which is approximately 75 km from the Wind Farm boundary.

8.2.9 Harbour seal often forage close to their haul-out sites, resulting in higher densities nearer to coastal areas in the inner Moray Firth (BOWL, 2012a; Bailey *et al.,* 2014). This observation is supported by the results of the 2014/2015 harbour seal tagging studies undertaken as part of the pre-construction MMMP. The 2015 interim results demonstrate that tagged harbour seals breeding at haul-out sites in the northern part of the Moray Firth forage predominantly in the inner Moray Firth, in the areas to the south west of the Wind Farm site, with relatively few individuals making longer-distance trips to the Development site or beyond (Graham *et al*., 2015). Distances travelled from haul-outs vary between life-stages, sexes and individuals and it is therefore difficult to determine any seasonal patterns in sensitivity.

8.2.10 Given the uncertainties regarding seasonal distribution and sensitivities, for the purposes of this PS, harbour seal is considered to be equally sensitive in all months of the year.

Harbour Porpoise

8.2.11 Studies have shown that Harbour porpoise occur year-round in the Moray Firth and are likely to be frequently present in the Wind Farm site (Thompson and Brookes 2011; Brookes etc. al 2013).

8.2.12 Harbour porpoise also occur along the southern Moray Firth coast on a high proportion of days in the year although detection rates are generally lower in coastal areas, where bottlenose dolphin occur more commonly, than in offshore areas (Thompson and Brookes, 2011). Harbour porpoise are likely to be present all year round and there is no evidence suggesting that individual harbour porpoises are more sensitive to noise disturbance at particular times of year therefore for the purposes of this PS, harbour porpoise is considered to be equally sensitive in all months of the year.

8.3 Atlantic Salmon

8.3.1 Due to some uncertainty in the extent to which migration and feeding behaviour could be affected by sound levels that occur away from the immediate vicinity of pile driving activity, a precautionary approach to the impact assessment was undertaken for Atlantic salmon. Adult Atlantic salmon and smolts migrating to and from rivers that enter the Moray Firth were considered to be of medium sensitivity to the disturbance effects of subsea noise arising from piling in the ES assessment (Paragraph 80, BOWL, 2012a), despite low overall sensitivity to sound. Adult salmon were not considered to be particularly hearing sensitive (Paragraph 74: BOWL, 2012a); hence adult salmon were only expected to exhibit strong avoidance reactions in close proximity to piling. For smolts evidence suggests that juvenile marine fish are no more sensitive to sound than adults (Annex 11B: BOWL, 2012a) and were also expected to exhibit strong avoidance reactions only in close proximity to piling (Paragraph 71: BOWL, 2012a). A key consideration in the assessment of the potential impacts was to avoid any 'noise barriers' between the Wind Farm and the Caithness coast which might otherwise potentially prevent migration along the coast.

8.3.2 Atlantic salmon were considered to be sensitive to noise emissions from piling when they were anticipated to migrate through the Moray Firth either as smolts on their way out form rivers that enter the Firth, or as adults returning to rivers to spawn. Smolt migration from rivers generally takes place between April and June (BOWL, 2012a). Peak numbers are usually recorded during the latter half of April and in May. Adult salmon are thought to migrate into the rivers of the Moray Firth during most months of the year. However, peak numbers are usually recorded during the summer months between May and October (BOWL, 2012a).

8.4 Herring

8.4.1 As a hearing sensitive species the ES (BOWL, 2012a) considered herring to be sensitive to piling noise-induced disturbance effects, particularly during the spawning period due to herring being substrate specific and spatially limited spawners. It was however noted that the main spawning areas of the Orkney/Shetland herring spawning stock are at considerable distance from the Development.

8.4.2 Spawning in the Moray Firth (and wider Orkney/Shetland stock) occurs during August and September (Coull *et al*., 1998). The peak spawning period for this stock is known to be variable between years and is likely to be more temporally limited than the commonly reported two month period.

8.4.3 The results from the herring larval surveys BOWL completed in August and September 2014 (BOWL, 2014a) show that the highest densities of herring larvae were recorded in mid-September (week 7) of the survey (see Figure 8.1 and 8.2) with 96.3% of the total catch recorded in mid to late September (weeks 6, 7 and 8 combined). Significantly lower abundances were recorded in August, indicating a single distinct spawning period (BOWL, 2014a). The back-calculation of larval hatch data indicated that the peak spawning period occurs in the first two weeks of September.

8.4.4 The spatial distribution of larvae by length indicated that, following hatching, larvae were transported in a southerly direction from the north of the sampling area (see Figure 6.19 to 6.24; BOWL, 2014a).

8.4.5 The International Herring Larvae Surveys (IHLS) recorded comparatively low numbers of herring larvae <10 mm (n/m^2) in the vicinity of the Development during surveys completed in 2012 (see Figure 8.1). The highest larval densities recorded by the IHLS surveys were found north of the survey area, in and around the Orkney and Shetland Islands (see Figure 8.2).

8.4.6 Analysis of data from the BOWL 2014 herring surveys using the age back-calculation from length estimates indicated that the mean age for the most prevalent size class recorded during the surveys (7.0 – 7.9 mm) is between 7.53 and 9.28 days, incorporating yolk sac absorption.

8.4.7 Hydrodynamic data for the area, derived from the literature, has produced estimates of residual current velocity ranging from 1 to 2 km/day to 7.0 to 8.6 km/day (Baxter *et al*., 2011; Guerin *et al*., 2014; Heath *et al*., 1989; Nichols, 1999; Turrell *et al*., 1990; UKMMAS, 2010). Using the residual velocity data with larval age, 7.0 to 7.9 mm larvae would travel a minimum of 7 to 18 km and up to 60 to 77 km following hatching. This suggests that the majority of the larvae caught during the survey had drifted down from the well-established spawning grounds in the Orkney and Shetland Islands as opposed to having been spawned within the Moray Firth. Based on these results it is apparent that the peak spawning activity in 2014 occurred in the first two weeks of September (BOWL, 2014a) and that the spawning occurs in the spawning grounds to the west of the Orkney and Shetland Islands. As a result the spawning herring are unlikely to be subjected to noise-induced disturbance from the Development, given the distance from this spawning ground.

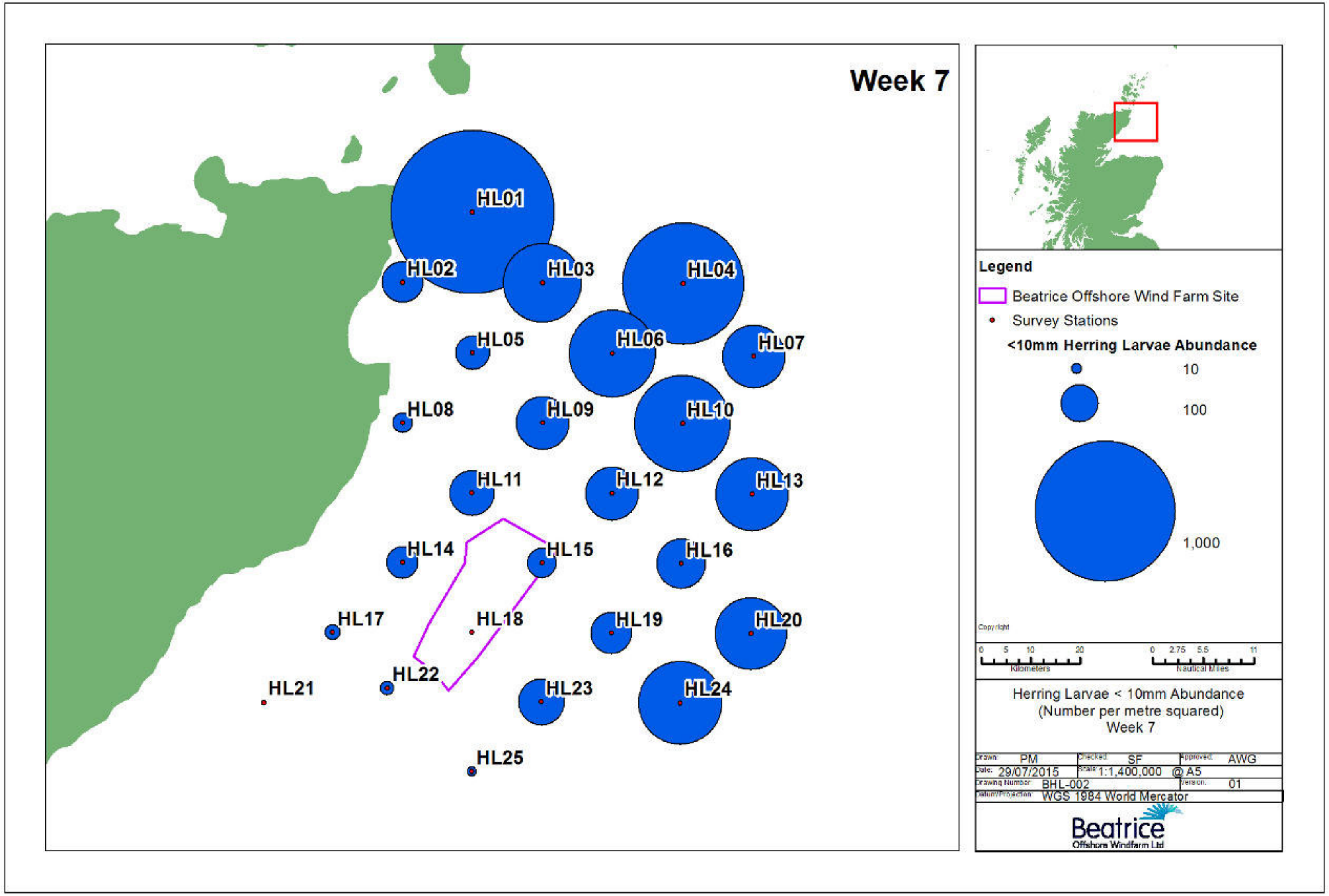


Figure 8.1 - Herring larvae abundance (n/m^2) during BOWL survey week 7 (15th – 19th September 2014)

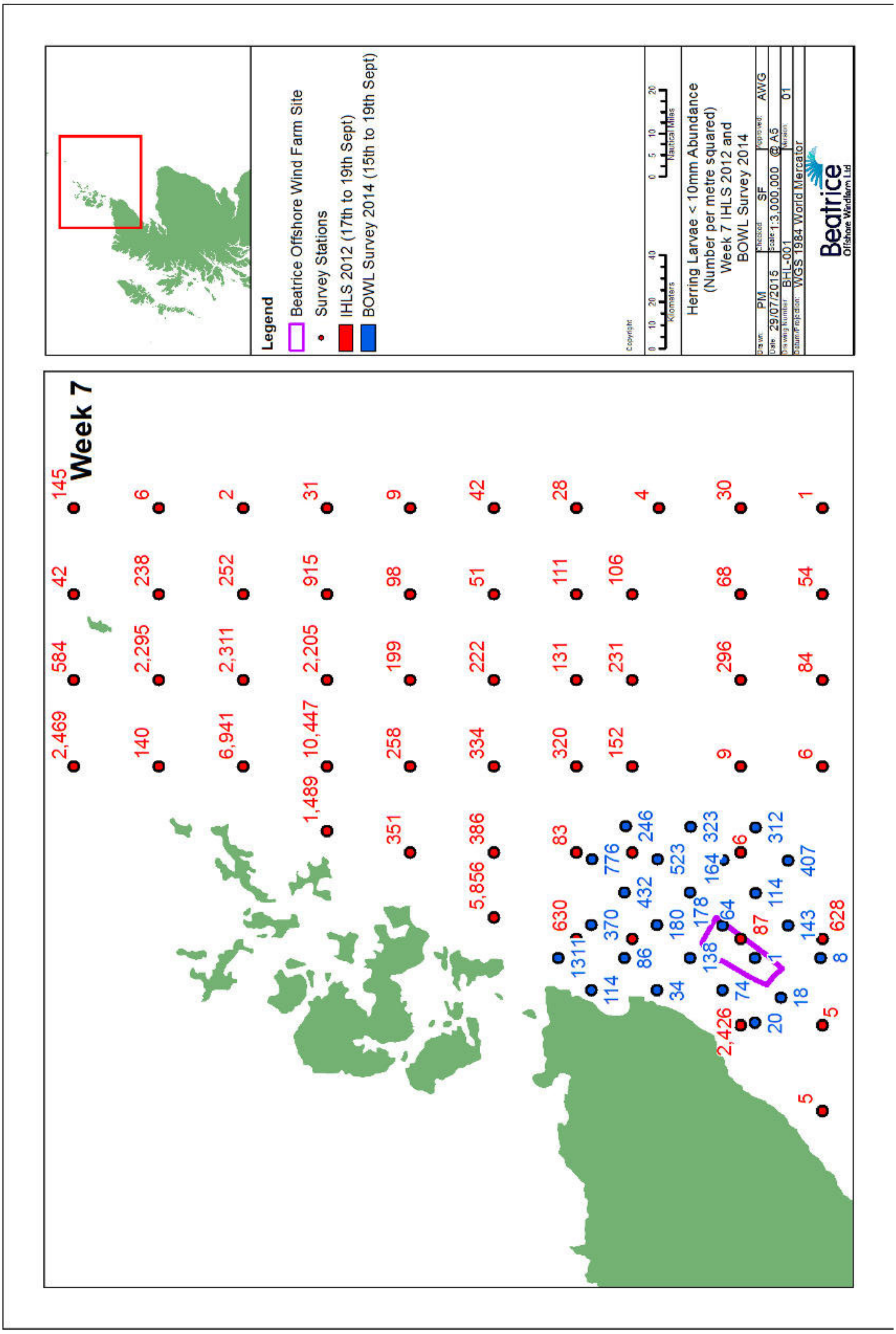


Figure 8.2 - Herring larvae abundance (n/m^2) week 7 IHLS 2012 and BOWL survey week 7

8.5 Cod

8.5.1 Cod spawn in the North Sea between January and April, with peak spawning generally understood to occur during February to March (Coull *et al.*, 1998). Eggs are pelagic and hatch over a period of two to three weeks, depending on water temperature (Wright *et al.*, 2003). The Moray Firth cod stock is reproductively isolated from other North Sea stocks and spawning grounds for this species have been identified in the area of the Development (i.e. Coull *et al.*, 1998 and Ellis *et al.*, 2010; see Figure 8.3).

8.5.2 Noise contour modelling undertaken for the ES showed potential overlap with cod spawning grounds.

8.5.3 BOWL completed cod spawning surveys in February and March 2014. These surveys were designed in conjunction with MSS and MS-LOT with the objective of characterising cod spawning potentially occurring within the 90 dB_{ht} noise ranges modelled for the Wind Farm. Cod catch rates in Catch Per Unit Effort (CPUE) were calculated and three categories assigned based on values provided by MSS:

- Not important for spawning cod (≤15 spawning cod/km^2);
- May be important for spawning cod (>15 to ≤ 75 spawning cod/km^2); and
- "Spawning area" (>75 spawning cod/km^2).

8.5.4 The surveys consisted of two trips, Trip 1 and Trip 2, carried out in February and March respectively. During Trip 1, three stations out of 19 surveyed had spawning cod catch rates that were considered to indicate a "spawning area" (see Figure 8.4). Trip 2 recorded four sampling stations out of 21 surveyed with spawning cod catch rates that were considered to indicate a "spawning area" (see Figure 8.5).

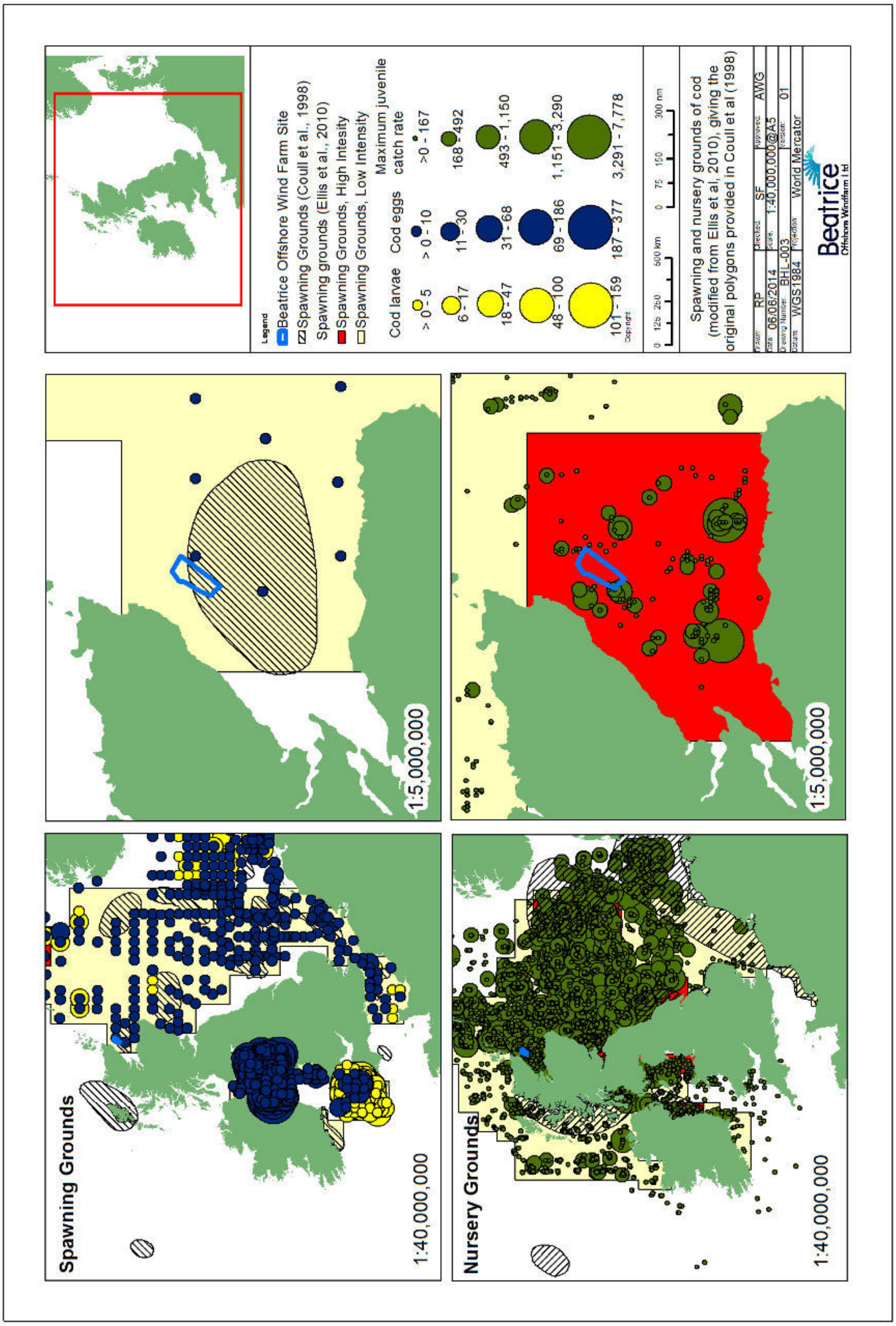


Figure 8.3 - Cod spawning grounds as mapped by Coull *et al.* (1998) and Ellis *et al.* (2010)

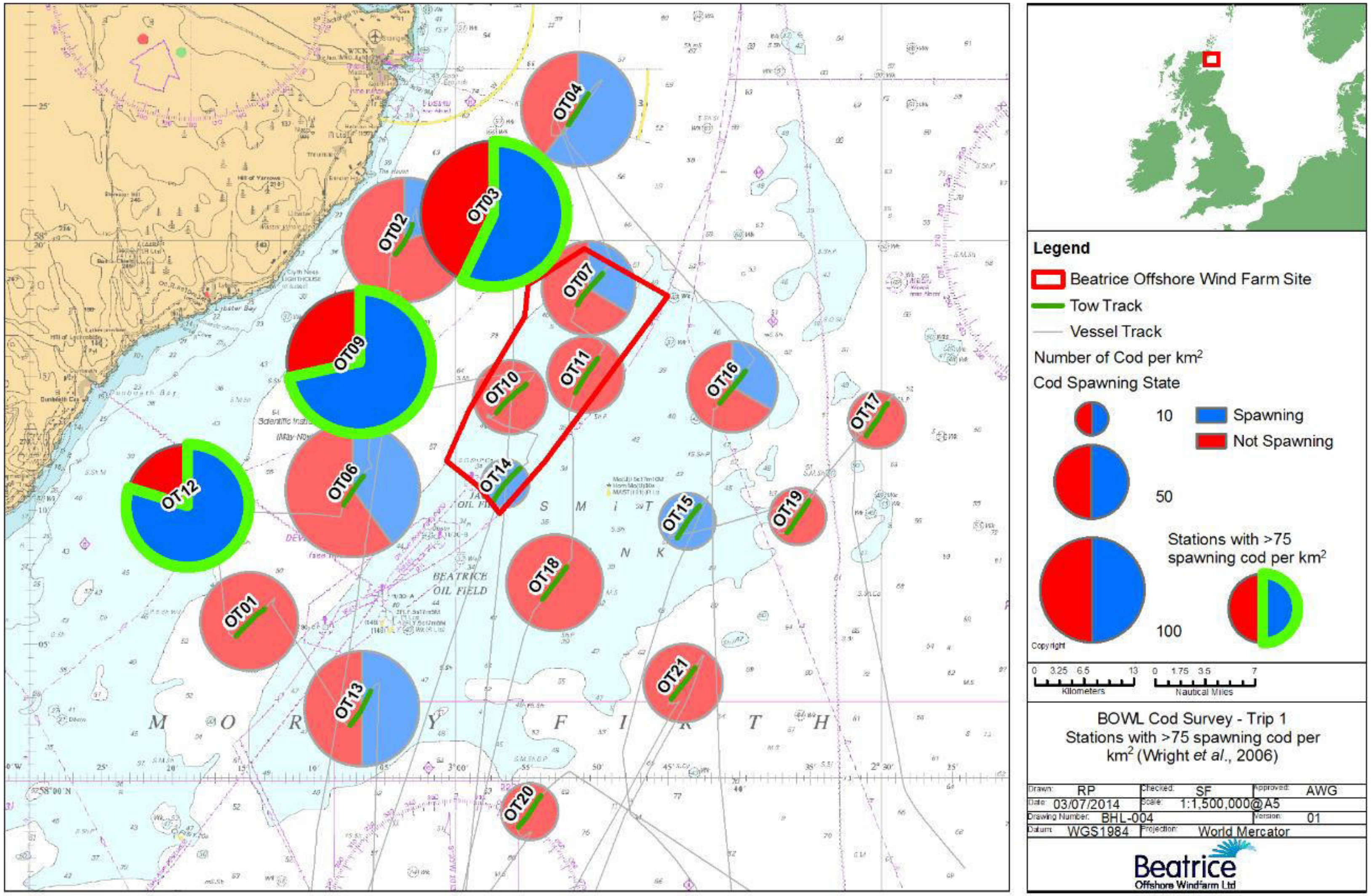


Figure 8.4 - Cod catch rates by CPUE (no. cod/km^2) for Trip 1 with stations showing >75 spawning cod/km^2 highlighted in green

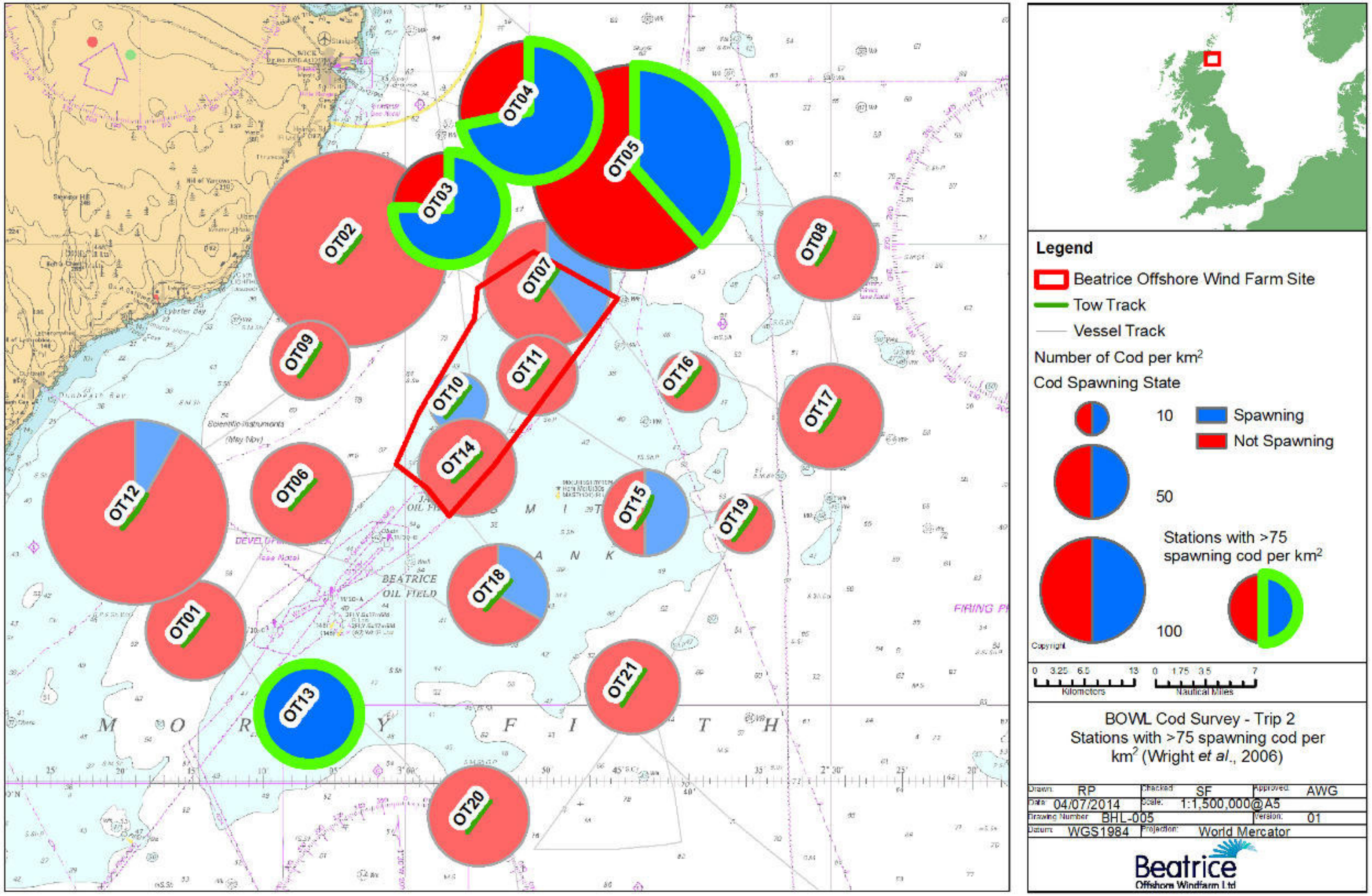


Figure 8.5 - Cod catch rates by CPUE (no. cod/km²) for Trip 2 with stations showing >75 spawning cod/km² highlighted in green

9 Reduction in Design Envelope in Comparison to the ES/SEIS

9.1 Introduction

9.1.1 This section of this PS compares the worst case project design scenarios assessed in the marine mammal and fish and shellfish ecology sections of the ES/SEIS against the refined project design parameters relevant to piling operations (Table 9.1). Further to this, a description of the resulting reduced potential spatial and temporal disturbance for each of the key species considered in this PS is provided.

Table 9.1 - Summary of the reduction in key engineering parameters relevant to this PS

Engineering Parameter	ES/SEIS Worst case	Refined Project Design	Anticipated reduction of key engineering parameters from worst case	
			Actual	**Reduction**
Number of piles	1,120 (277 WTGs, 3 met masts (monopiles), 3 OSPs)	352 (84 WTGs, 2 OTMs (plus 2 spare WTG locations only to be used if necessary))	768	**69%**
Anticipated hammer energy at each wind turbine/OTM location	2,300 kJ @ all locations	72 locations @ 1,200 kJ 11 locations @ 1,800 kJ 5 locations @ 2,300 kJ	1,100kJ @ 72 locations 500kJ @ 11 locations 0kJ @ 5 locations	**48%** **22%** **0%**
Anticipated piling duration (per pile)	5 hours	Up to 3.2 hours	1.8 hours	**35%**
Anticipated duration piling for the entire Development	33.4 weeks	Up to 6.8 weeks	26.6 weeks	**80%**
Total piling programme	3 years (36 months)	14 months (split into two phases of 8 and 6 months)[3]	22 months	**61%**

[1] Piling phasing is planned over this period, however piling is possible but unlikely from December2017 to March 2018.

9.1.2 The refined project design when compared to the ES/SEIS worst case results in a considerably reduced piling duration and the likely considerable reduction in the proportion of piling at the maximum consented hammer energy of 2300 kJ. Consequently there will be a marked reduction in potential temporal and spatial disturbance to both fish and marine mammal species.

9.2 Temporal Reduction in Potential Disturbance

9.2.1 As set out in Table 9.1, the 69% reduction in the number of piled foundations from the worst case of 1,120 assessed in the ES to 352 has contributed to an anticipated 22 month (61%) reduction in the overall period required for the piling of foundations compared to the worst case 3 year period considered in the ES.

9.2.2 Cumulative total piling duration is estimated at a maximum of 6.8 weeks, or a maximum of circa 11.2% of the total foundation installation period (and 80% less than that assessed in the ES). This re-enforces the point that piling will occur as intermittent short-duration events within the overall installation period.

9.2.3 As a result, the information in Table 9.1 demonstrates a considerable reduction in the duration of potential behavioural disturbance for marine mammals and spawning herring and cod, and migrating Atlantic salmon. It is also the case that noise emissions resulting from pile –driving will be temporary in nature and intermittent.

9.3 Spatial Reduction in Potential Disturbance

9.3.1 As set out in Section 7.3, although the maximum hammer energy at each location could be up to the consented maximum of 2300kJ, the more realistic anticipated piling hammer energies that will be used across the Wind Farm are 1200 kJ, 1800 kJ and 2300 kJ and the pile diameter is 2.2 m. 1200 kJ is estimated to be the most commonly required hammer energy at the majority of locations across the site where substrate resistance is low to medium, whilst 1800 kJ or 2300 kJ is estimated to be the upper energy required but at a smaller number of locations where substrate resistance is higher. 2300 kJ also represents the maximum consented hammer energy.

9.3.2 This represents a marked reduction in the total energy required for pile installation compared to the worst case considered in the ES and SEIS where the maximum consented energy of 2,300kJ was assumed at 1,120 pile locations.

Noise modelling

9.3.3 To demonstrate the effect of the reductions in both pile size and hammer energy, Subacoustech Environmental Ltd, on behalf of BOWL, re-modelled the spatial extent of received noise levels in frequencies relevant to bottlenose dolphin, harbour seal, harbour porpoise, Atlantic salmon, cod and herring for a 2.2m diameter pile and using the predicted hammer energies (1200kJ, 1800kJ and 2300kJ), The same noise modelling approaches applied in the ES and SEIS (Section 12.2.7.9 in the Wind Farm ES; BOWL, 2012a) were also applied here. The locations modelled were species-specific and were selected so as to predict the greatest spatial extent of behavioural disturbance for each species.

9.3.4 The metric used to compare potential behavioural disturbance from these received noise levels was the 90 dB_{ht} (Species) threshold for avoidance (with the exception of Atlantic salmon, where a 75 dB_{ht} (Species) threshold was also considered). In the ES, slightly different approaches were used to assess potential disturbance for fish and marine mammals, with the marine mammal assessments using a dose-response relationship rather than a simple 75 or 90 dB_{ht} (Species) threshold. However, to provide comparisons in the spatial extent of potential noise disturbance from the refined project with that set out in the ES, changes in the area within the 90 dB_{ht} (Species) (or where appropriate the 75 dB_{ht} (Species)) thresholds were modelled.

9.3.5 The areas within which these weighted received levels would be exceeded when using the revised pile size and revised hammer energies were compared with the equivalent values presented in the ES. Comparison of the 2.2 m diameter pile with the 2.4 m diameter pile at the same hammer energy, for most species, resulted in only minor reductions in the spatial extent of potential disturbance.

9.3.6 The most noticeable differences resulted from a reduction in hammer energy from the worst case 2,300 kJ to 1,200 kJ (the hammer energy predicted for the majority of locations - see Section 7.3).

9.3.7 The resulting reduction in the area of potential spatial disturbance for each of the key species is set out in the sections below.

Marine mammals

9.3.8 Table 9.2 below sets out the size of the predicted areas within which modelled noise levels, weighted for bottlenose dolphin, harbour seal and harbour porpoise hearing, exceed the 90 dB_{ht} levels. Predictions are presented for the anticipated range of pile hammer energies to be used in the refined project. For comparison, predictions from the worst case scenario considered in the ES (2300 kJ hammer and a 2.4 m diameter pile) are presented in the first column of Table 9.2. The numbers presented in parentheses show the percentage reduction in total area of avoidance when compared to the worst case avoidance areas presented in the ES.

9.3.9 For all marine mammal species, there is a reduction (up to 34%) in potential spatial disturbance from individual piling events when using the anticipated lower piling hammer energy when compared to the worst case maximum consented hammer energy of 2300 kJ (Table 9.2).

Table 9.2 – Comparison of areas within which received noise levels are predicted to exceed 90 dB_{ht}, weighted for bottlenose dolphin, harbour seal and harbour porpoise hearing (for the hammer energies and pile sizes in the refined project design and for the worst case scenario assessed in the ES (cells shaded grey).

Noise contour	2.4 m diameter pile @ 2300 kJ	2.2 m diameter pile @ 2300 kJ	2.2 m diameter pile @ 1800 kJ	2.2 m diameter pile @ 1200 kJ
Bottlenose dolphin				
90 dB_{ht}	*737 km²*	*734 km² (-0.4%)*	*631 km² (-14.4%)*	*486 km² (-34.1%)*
Harbour seal				
90 dBht	*1122 km²*	*1129 km² (-0.6%)*	*972 km² (-13.4%)*	*740 km² (-34.0%)*
Harbour porpoise				
90 dBht	*1533 km²*	*1537 km² (-0.3%)*	*1351 km² (-11.9%)*	*1083 km² (-29.4%)*

Fish Species

9.3.10 For fish species the main focus of the assessments presented in the ES was the potential for behavioural disturbance during spawning or migrations as a result of noise emissions from piling operations. As detailed in Section 11.4.1.2 of the ES (BOWL, 2012a), the noise criteria used to re-model the spatial extent of potential behavioural disturbance on fish species in this PS were based on the 90 dB_{ht} (species) model outputs, as this is the level at which the strongest avoidance reactions are expected. Consideration is also given to the more precautionary 75 dB_{ht} (species) model outputs for Atlantic salmon, due to the potential for 'barrier effects' on this migratory species, if noise disturbance were to extend to the coast. The 75 dB_{ht} (species) criteria represent the noise levels at which milder disturbance, probably transient and limited by habituation, could occur.

9.3.11 Noise modelling locations for key fish species were selected to be comparable with the worst case scenario presented in the ES and SEIS and where noise contours would be more likely to affect sensitive areas, such as spawning grounds.

Atlantic Salmon

9.3.12 Table 9.4 below sets out the changes in the size of the areas within which received noise levels weighted for Atlantic salmon hearing could exceed 75 dB_{ht} and 90 dB_{ht} for the different hammer energies proposed and using the 2.2m pile diameter and by comparison to the ES worst case scenario (2300 kJ hammer and 2.4 m diameter pile). The numbers presented in parentheses show the percentage reduction in total area of predicted avoidance when compared to the worst case avoidance areas presented in the ES.

Table 9.4 – Comparison of areas within which received noise levels are predicted to exceed 75 dB_{ht} and 90 dB_{ht}, weighted for Atlantic salmon hearing (for the hammer energies and pile sizes in the refined project design and for the worst case scenario assessed in the ES (cells shaded grey).

Noise contour	2.4 m diameter pile @ 2,300 kJ	2.2 m diameter pile @ 2,300 kJ	2.2 m diameter pile @ 1,800 kJ	2.2 m diameter pile @ 1,200 kJ
90 dB_{ht}	*15.18 km²*	*12.40 km²* (-20%)	*9.36 km²* (-39%)	*5.85 km²* (-62%)
75 dB_{ht}	*444.60 km²*	*412.37 km²* (-15%)	*334.97 km²* (-31%)	*233.43 km²* (-52%)

9.3.13 Figure 9.1 shows the noise contours modelled for the scenarios set out in Table 9.4 at Location C; the closest location in the Wind Farm to the Caithness coast. The noise contours demonstrate the lack of any potential 'barrier' effects associated with piling noise between the Wind Farm site and the Caithness coast. The figure also shows that the use of lower piling energies will lead to a marked increase in the distance between the noise contours and the Caithness coast.

9.3.14 The predicted reduction in potential spatial behavioural disturbance set out in Table 9.4 and the noise contours shown in Figure 9.1 demonstrate that:

- only a small proportion of the Atlantic salmon habitat in the Moray Firth will be affected;
- there will be no 'barrier' effects on adult migration to spawning rivers; and
- there will be no 'barrier' effects on seaward migrating smolt.

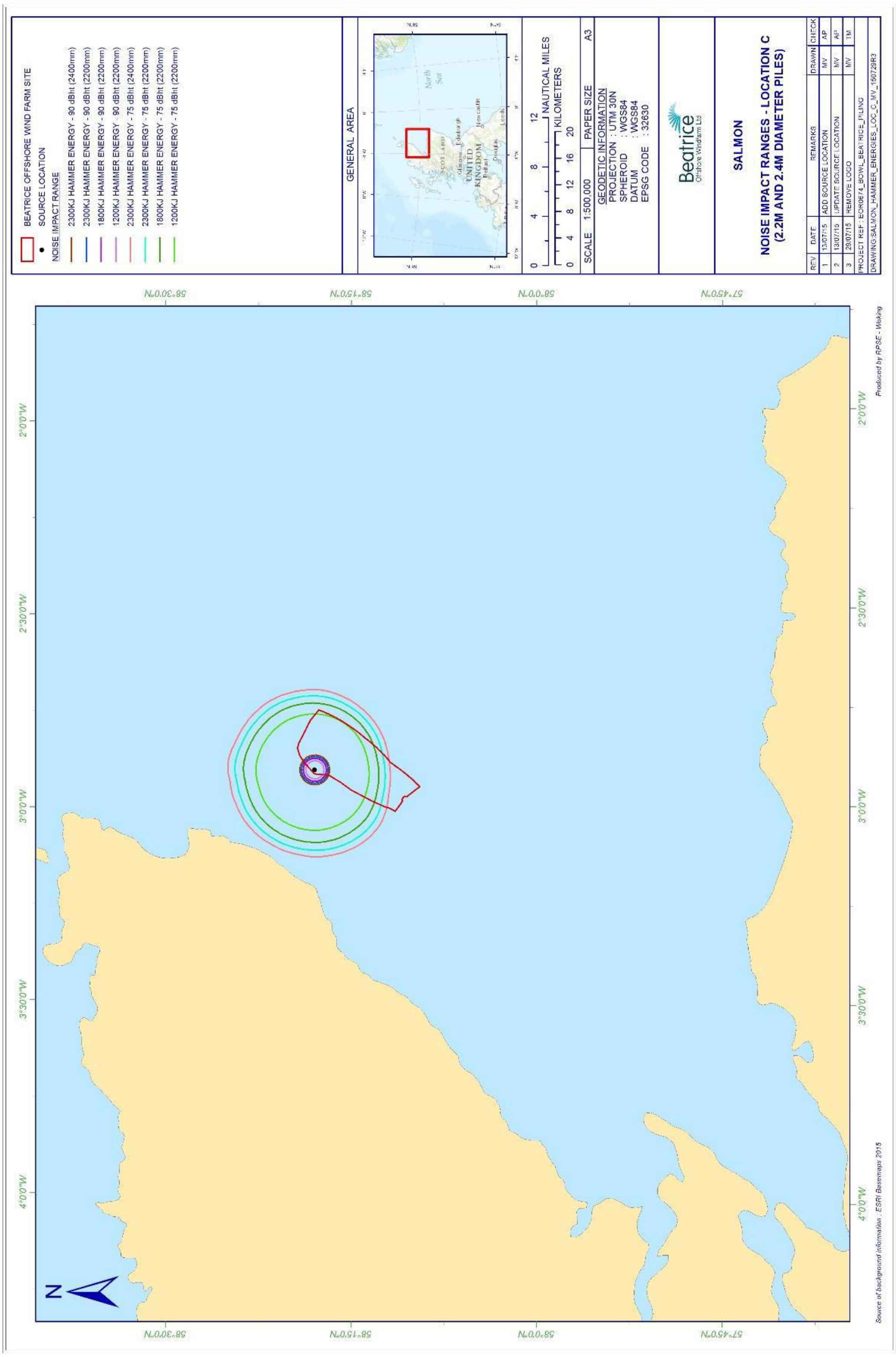


Figure 9.1 -- Noise Contours (75 and 90 dBht) for Atlantic Salmon for piling at Location C

Herring

9.3.15 Table 9.5 below sets out the changes in the size of the areas within which received noise levels weighted for herring hearing could exceed 90 dB_{ht} for the different hammer energies proposed and using the 2.2m pile diameter and by comparison to the ES worst case scenario (2300 kJ hammer and 2.4 m diameter pile). The numbers presented in parentheses show the percentage reduction in total area of avoidance when compared to the worst case avoidance areas presented in the ES.

Table 9.5 - Comparison of areas within which received noise levels were predicted to exceed 90 dB_{ht}, weighted for Herring hearing (for the hammer energies and pile sizes in the refined project design and for the worst case scenario assessed in the ES (cells shaded grey).

Noise contour	2.4 m diameter pile @ 2,300 kJ	2.2 m diameter pile @ 2,300 kJ	2.2 m diameter pile @ 1,800 kJ	2.2 m diameter pile @ 1,200 kJ
90 dB_{ht} (likely avoidance)	*2,844 km^2*	2,686 km^2 (-5.57%)	2,363 km^2 (-16.90%)	1,891 km^2 (-33.51%)

9.3.16 Figure 9.2 shows the noise contours modelled for the scenarios set out in Table 9.5 at Location D, the closest location in the Wind Farm to the herring spawning grounds.

9.3.17 Table 9.5 and Figure 9.3 show that the potential for behavioural disturbance to spawning adult herring has been significantly reduced when compared to the worst case scenario assessed in the ES.

9.3.18 Data gathered during the BOWL site specific herring larval survey described in Section 8.4 and from the annual International Herring Larval Surveys (IHLS), both indicated a general pattern of higher larval abundance at more northerly locations. As shown in Figure 9.3, the noise contours derived from the modelling of each of the revised piling scenarios has resulted in a southerly contraction of the arc of the 90 dB_{ht} away from the larval sampling stations which have historically yielded the highest herring larval densities, when compared to the ES worst case scenario.

9.3.19 In the case of the IHLS data almost all of these sampling stations are located outside the 90 dB_{ht} noise contours produced by the modelling of all of the piling scenarios. With reference to the site specific survey commissioned by BOWL, the use of a 1,800 kJ hammer energy would result in a number of stations recording higher abundances being located outside the 90 dB_{ht} noise contour and with a greater number of stations still excluded when considering the noise contours derived by the modelling of the 1,200 kJ hammer.

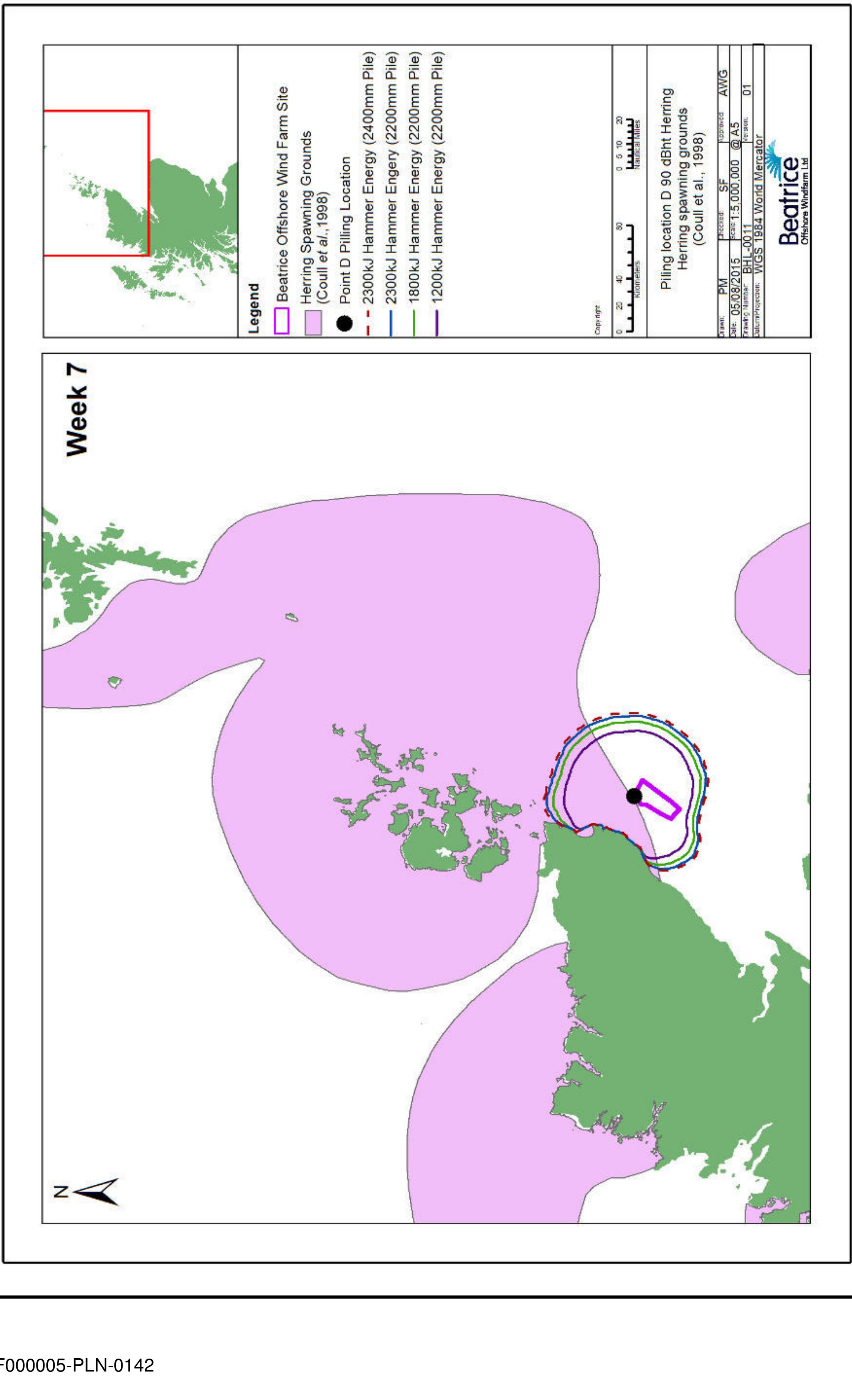


Figure 9.2 - Noise Contours (90 dBht) for Herring for piling at Location D

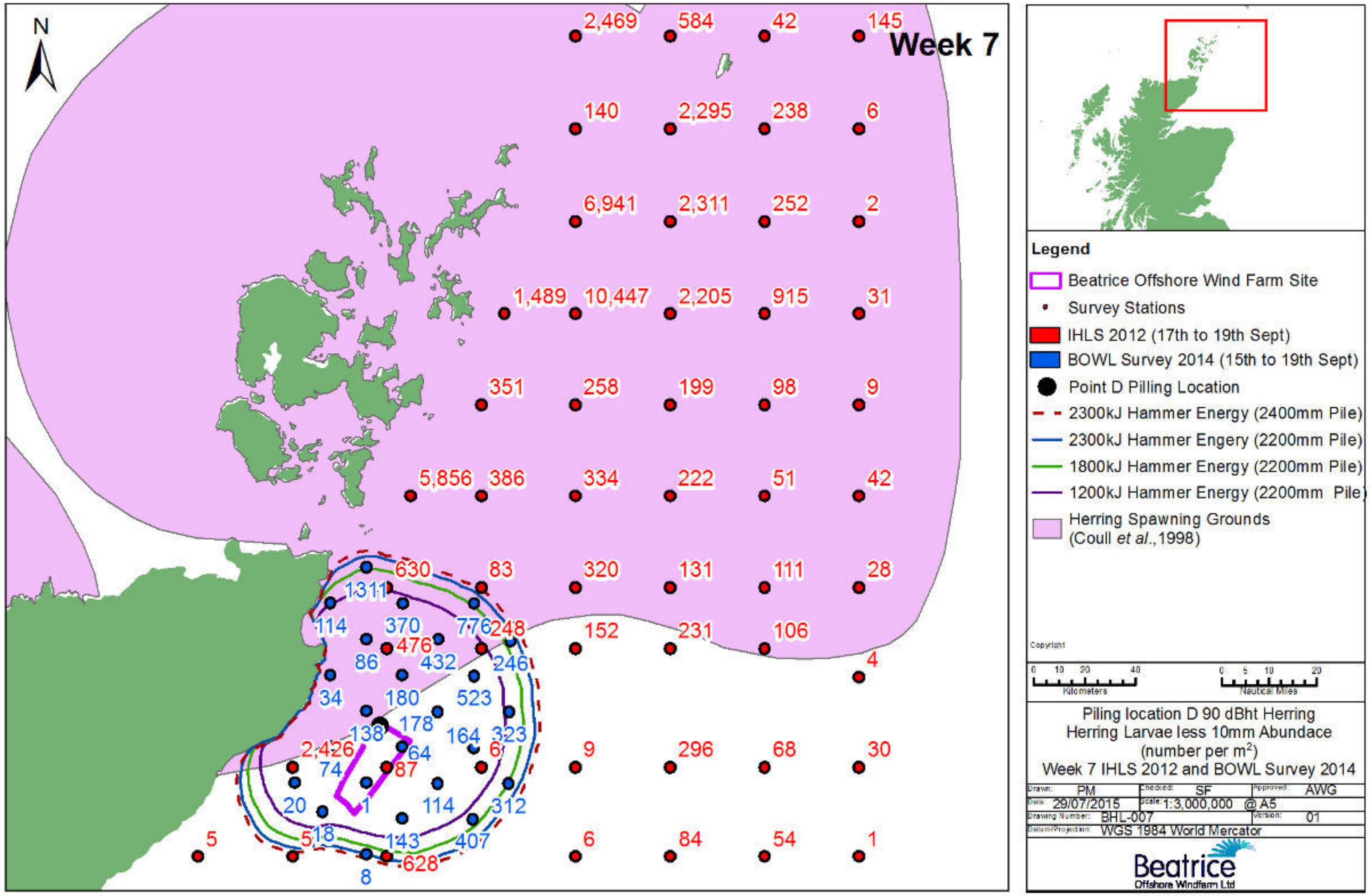


Figure 9.3 - Noise Contours (90 dBht) for Herring for piling at Location D overlaid on data from the BOWL 2014 herring survey data (week 7) and the ILHS 2012 (week 7) data

Cod

9.3.20 Table 9.6 below sets out the changes in the size of the areas within which received noise levels weighted for cod hearing could exceed 90 dB_{ht} for the different hammer energies proposed and using the 2.2m pile diameter and by comparison to the ES worst case scenario (2300 kJ hammer and 2.4 m diameter pile). The numbers presented in parentheses show the percentage reduction in total area of avoidance when compared to the worst case avoidance areas presented in the ES.

Table 9.6 - Comparison of areas within which received noise levels are predicted to exceed 90 dB_{ht}, weighted for cod hearing (for the hammer energies and pile sizes in the refined project design and for the worst case scenario assessed in the ES (cells shaded grey).

Noise contour	2.4 m diameter pile @ 2,300 kJ	2.2 m diameter pile @ 2,300 kJ	2.2 m diameter pile @ 1,800 kJ	2.2 m diameter pile @ 1,200 kJ
90 dB_{ht} (likely avoidance)	*1,836 km²*	*1,636 km²* (-10.88%)	*1,393 km²* (-24.11%)	*1,045 km²* (-43.09%)

9.3.21 Figure 9.4 shows the noise contours modelled for the scenarios set out in Table 9.6 at Location A, the closest location in the Wind Farm to the cod spawning grounds defined by Coull *et al*. (1998) and Ellis *et al*. (2010). These are located immediately south of the Development.

9.3.22 The reductions in the area of potential spatial disturbance under the three piling scenarios are generally greater than those predicted for herring. This is likely to be a reflection of the reduced hearing sensitivity of cod compared to herring and the different ground conditions at location A when compared to C incorporated into the model. For cod, the greatest reductions in impacted area are evident for the 1,200 kJ (43.09%) and 1,800 kJ (24.11%) hammer energies.

9.3.23 Results from the pre-construction cod spawning surveys completed in February and March 2014 show that ~17% of sampled stations could be classified as spawning areas under the agreed criteria. Figures 9.5 and 9.6 show the number of sample sites at which spawning was considered to have occurred and which fall within the 90 dB_{ht} noise contour; these numbers are reduced by around 50% when piling at 1200 kJ as opposed to 2300kJ.

9.3.24 The noise modelling indicates that the noise emitted from piling at a reduced hammer energy would result in a reduced area of potential behavioural disturbance to spawning aggregations of cod.

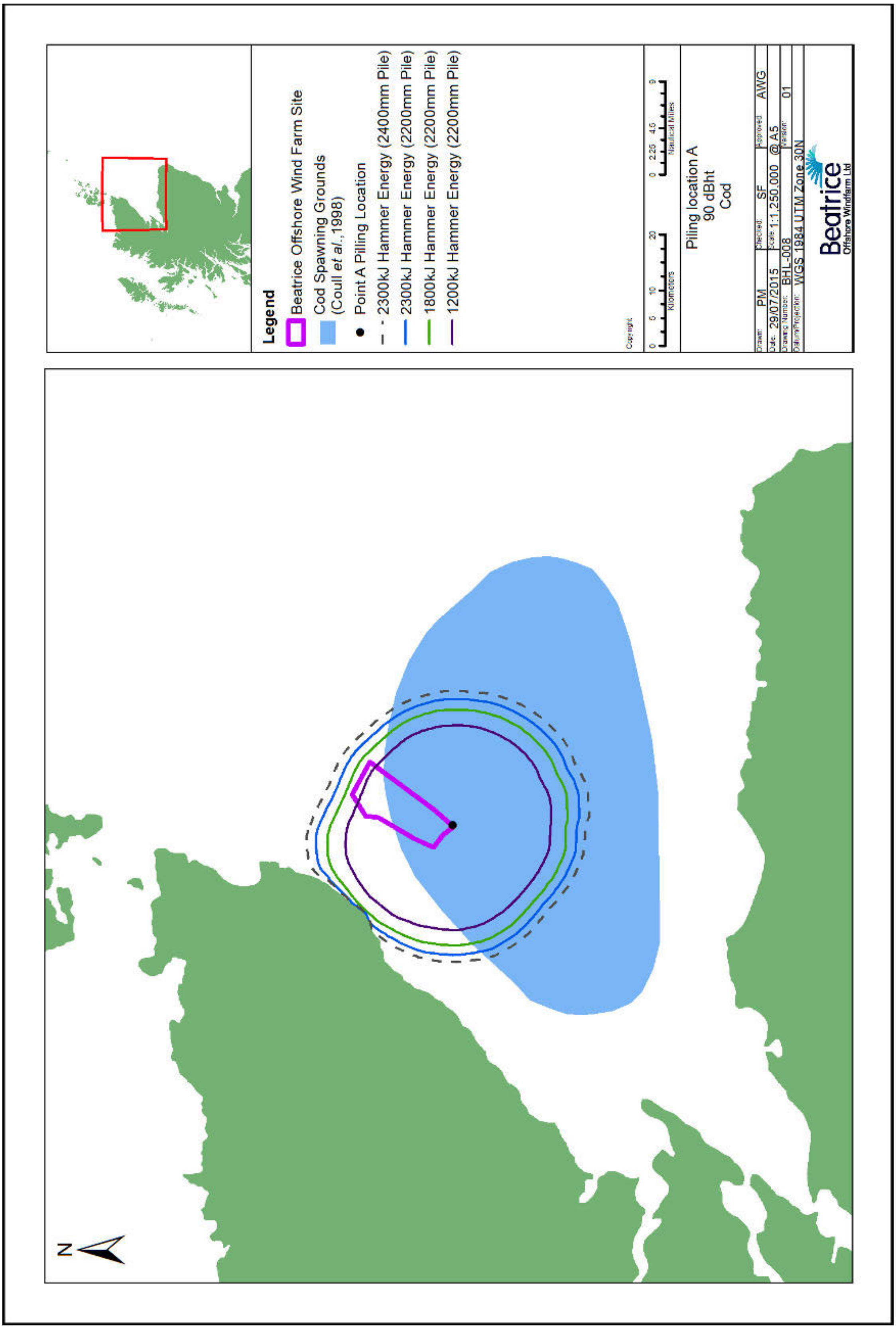


Figure 9.4 - Noise Contours (90 dBht) for Cod for piling at Location A

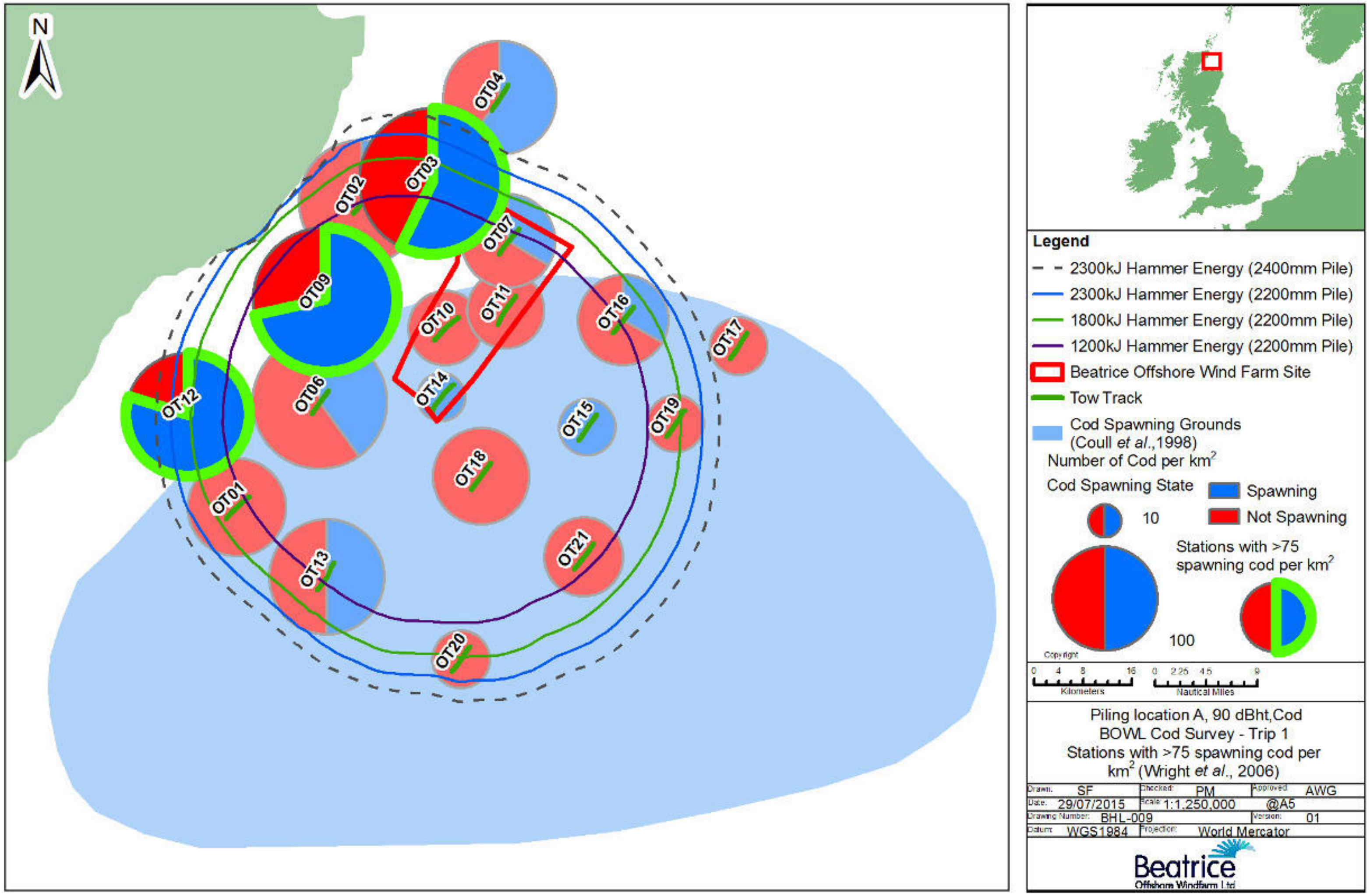


Figure 9.5 - Noise Contours (90 dBht) for Cod for piling at Location A overlaid on data from the BOWL 2014 cod survey data (Trip 1) for sampling stations with > 75 cod per km^2

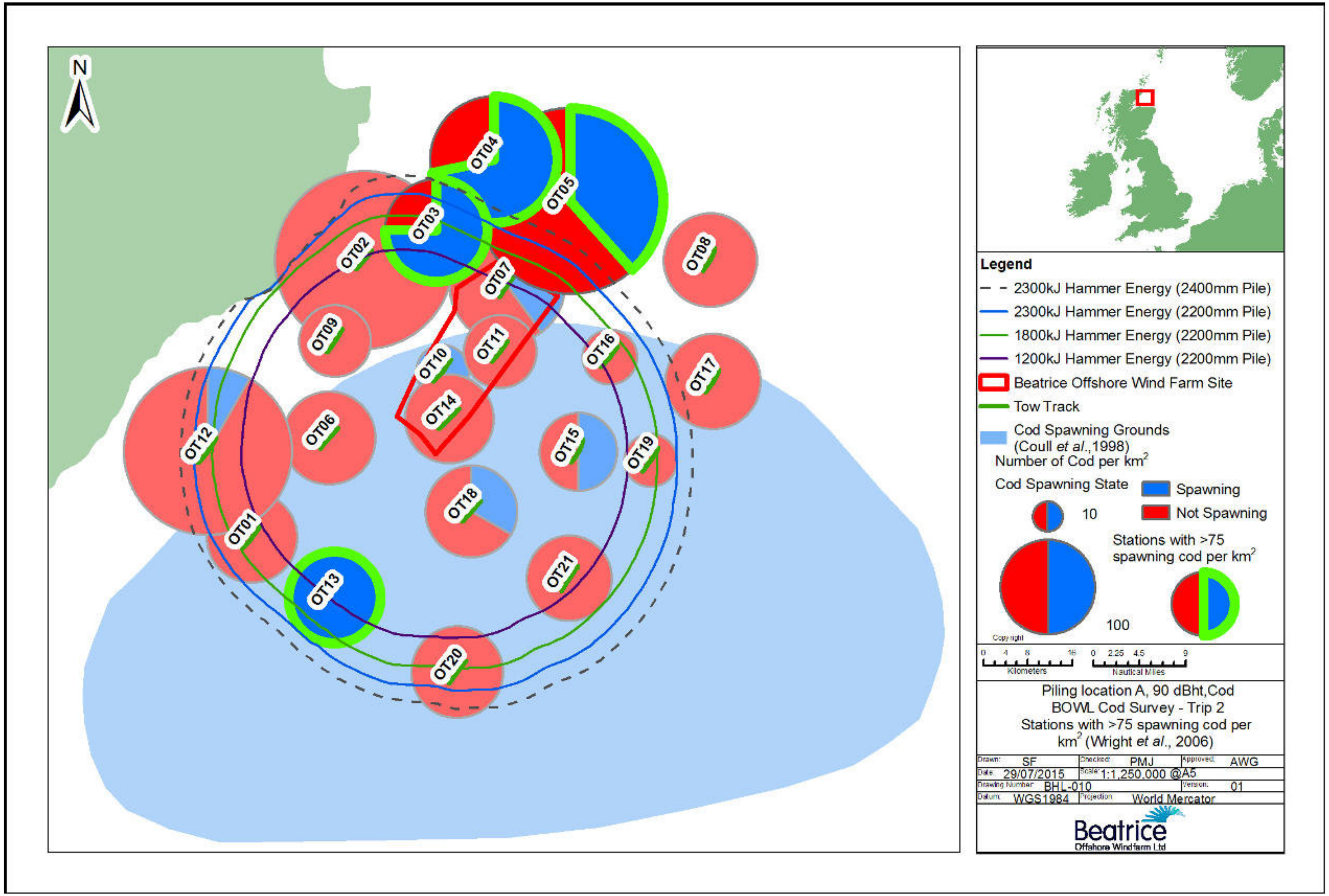


Figure 9.6 - Noise Contours (90 dBht) for Cod for piling at Location A overlaid on data from the BOWL 2014 cod survey data (Trip 2) for sampling stations with > 75 cod per km^2

10 Mitigation

10.1 Introduction

10.1.1 The S36 Consent Condition 12b and c and Marine Licence (OfTW) Condition 3.2.2.5 b and c set out the requirement for this PS to include:

> *b. Details of soft-start piling procedures and anticipated maximum piling energy required at each pile location;*
>
> *c. Details of mitigation and monitoring to be employed during piling, as agreed by the Scottish Ministers.*

10.1.2 This section provides details of the Piling Mitigation Protocol BOWL will implement to mitigate the risk of instantaneous death or injury to marine mammals during piling. Soft-start piling forms part of this Piling Mitigation Protocol. Mitigation for fish is also described.

10.2 Mitigation for Marine Mammals Including Details of the Soft Start Procedure

10.2.1 The potential impacts of noise emitted from piling on the key marine mammal populations, as considered in the ES and SEIS as part of the EIA process are noted under Section 8.2.

10.2.2 Mitigation for instantaneous death and injury for marine mammals was not assessed in the BOWL ES as it was assumed that close range impacts resulting in instantaneous death or injury would be avoided through the adoption of the 2010 JNCC piling guidelines when assessing the population consequences of piling activity (BOWL 2012 a and Annex 3 of Appendix D).

10.2.3 However, subsequent post-consent discussions with relevant stakeholders (see Section 4 and Table 4-1) have highlighted the need to develop an alternative approach to mitigating against instantaneous death and injury, integrating engineering requirements with new mitigation procedures and ensuring both a predictable and efficient process that balances environmental protection with commercial practicality.

10.2.4 Further to these discussions, BOWL have developed a Piling Mitigation Protocol in conjunction with MORL and the University of Aberdeen (see Appendix D). At the MFRAG Marine Mammal subgroup meeting on 19th June there was broad consensus within the Group that principles of the Piling Mitigation Protocol were acceptable, although there was a difference in views on the need or not to employ additional mitigation measures alongside ADDs.

10.2.5 The key steps set out in detail in the Piling Mitigation Protocol are outlined in the following sections.

Step 1: Optimise Hammer Energies

10.2.6 The Piling Mitigation Protocol seeks to optimise hammer energies to balance environmental risk and engineering requirements. Section 7 of this PS outlines how the geotechnical data collected to date has been analysed to predict the anticipated piling energies and durations required at each turbine / OTM location. Section 9 describes the significant reduction in both the duration of piling, and the amount of time piling is anticipated to be required at the maximum consented piling energy of 2300kJ, against that assessed in the ES/SEIS.

Step 2: Identify Injury Zone

10.2.7 The extent of the zone for instantaneous death and injury (the 'injury zone) has been defined through noise modelling of a 300 kJ soft start hammer energy (single strike) using the most precautionary criteria (i.e. 179 dB re 1 $\mu Pa^2 \cdot s$ for harbour porpoise; Lucke *et al*., 2009). The results of this modelling demonstrated that the maximum radius of effect for the onset of auditory injury, (otherwise known as a Permanent Threshold Shift (PTS)) for all marine mammals is 60 m. The 'injury zone' has therefore been identified as 60 m (Annex 1 in Appendix D).

Step 3: Develop Site Specific protocol for Piling Mitigation

10.2.8 This crucial step involves the deployment of an ADD and the implementation of a piling soft start to effectively deter marine mammals from the injury zone before piling commences (See Figure 10.1 and Appendix D).

10.2.9 The use of ADD plus a piling soft start for initiating piling would allow a marine mammal to clear the injury zone of 60 m and beyond to a distance of 2 to 3 km (based on the assumption that an animal will flee the noise in a direct line away from the source (see Figure 1 in Appendix D)).

ADD Deployment Protocol

10.2.10 An ADD Deployment Protocol setting out the details of ADD deployment has been developed by BOWL, and is described in detail in Appendix C. Key information set out in the Protocol includes, but is not limited to, the following;

- Details on the Lofitech ADD device with technical specifications;
- Role of the ADD operator, including training requirements and experience;
- Task plan to illustrate how mitigation will be carried out through communication with the SHL Offshore Manager. This includes a flow chart setting out, at each step, points of confirmation to ensure that the process is completed according to specification before the commencement of piling soft start;
- Method for testing that the ADD device is functioning effectively; and
- Location of deployment on-board the HLV.

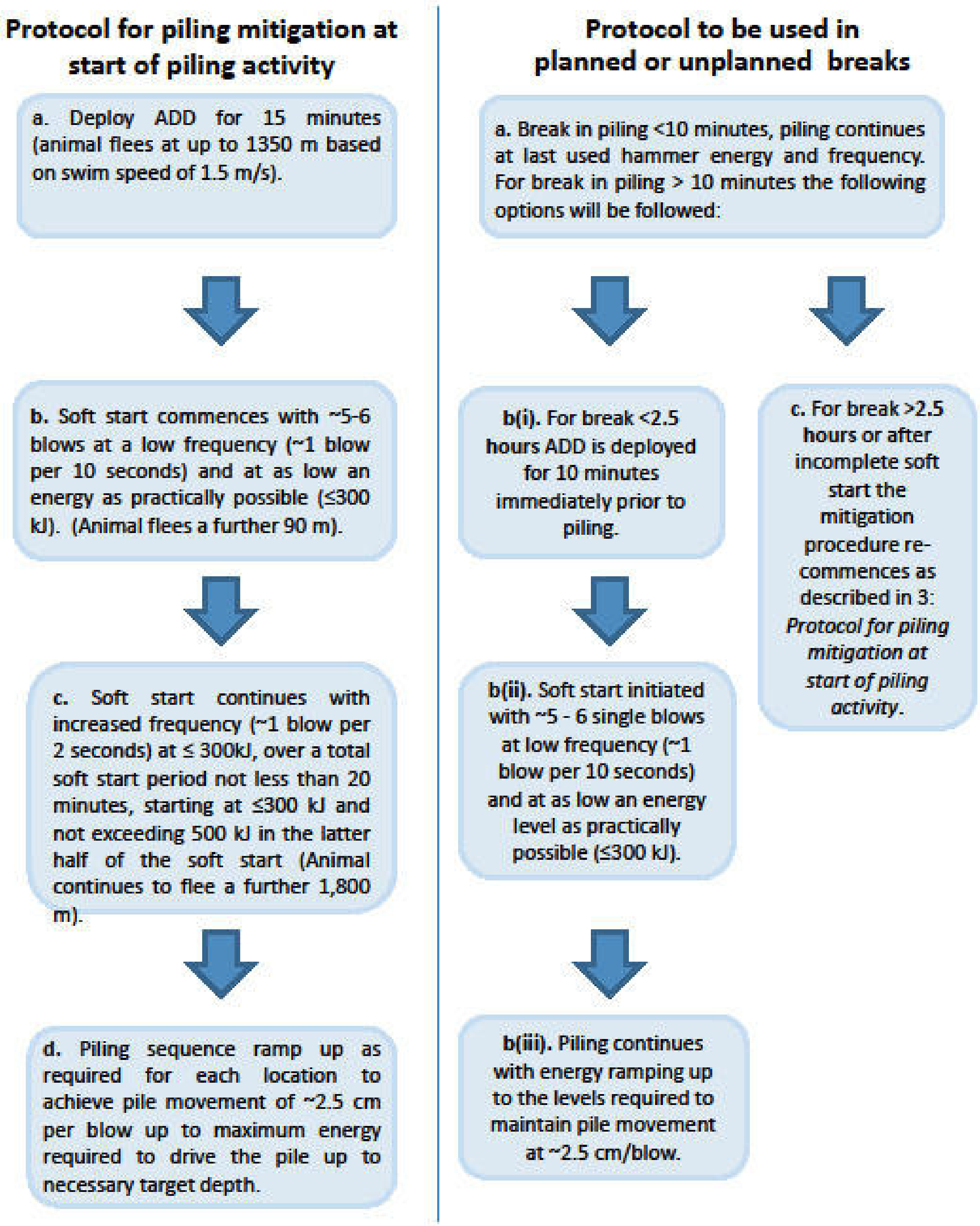
10.2.11 The piling soft start will not commence until the SHL Offshore Manager (role as described in Section 3) has confirmation from the ADD Operator (role as described in Section 3) that the ADD is functioning according to specifications and has been operating for a period of 15 minutes as specified in the Piling Mitigation Protocol (Appendix D).

Step 4: Develop Protocol for Planned or Unplanned breaks

10.2.12 Section 6.4 provides a description of planned and unplanned breaks that may occur during piling operations. The Piling Mitigation Protocol outlines a procedure to be implemented in the event of planned or unplanned breaks to ensure that marine mammals clear the injury zone before piling recommences (See Figure 10.1 and Appendix D).

10.2.13 The procedure for deployment of the ADD device is described in Appendix C.

Figure 10.1 - Summary of Piling Mitigation Protocol to be applied



Step 5: Monitor and Audit

10.2.14 The Piling Mitigation Protocol sets out the requirement to establish an agreed monitoring system and an audit trail to demonstrate that:

a. The ADD is operating according to specifications during all operations. Further information is provided in Appendix C of this PS.

b. Hammer energies remain within agreed limits within soft start periods. Further information is provided in Section 13 in this PS (reporting).

Step 6: Risk Assessment

10.2.15 To inform decisions about the potential risk of implementing the Piling Mitigation Protocol, as an alternative to the mitigation detailed in the JNCC 2010 Guidelines (JNCC, 2010) an assessment of the potential risk to different marine mammal species in the absence of any piling mitigation has been developed and is presented in Annex 3 of Appendix D. The analyses undertaken suggest that, in the absence of any piling mitigation, the risk of marine mammals being within sufficiently close range to result in instantaneous death or injury is negligible.

10.2.16 In addition, the Harbour Seal Assessment Framework was used to re-assess the long-term population consequences for this key receptor species. In doing so, the effects of post-consent changes in the project design and construction programme were compared to the original worst case ES scenarios.

10.2.17 The risk assessment looked at the potential effects on the population based on an assumption that mitigation did not work as predicted and compared this to the original population model considered within the ES (BOWL, 2012a) and report to inform the Habitats Regulations Assessment (HRA) (BOWL, 2012b). The results showed that the absence of effective mitigation against instantaneous death or injury had no discernible population level impact when constructing the BOWL and MORL Phase 1 Wind Farms (see Annex 3 of Appendix D for details).

10.3 Mitigation for Fish

Mitigation for Herring

10.3.1 Section 8.4 has set out the results of the first BOWL site specific herring larval survey which have indicated that the majority of larvae sampled in 2014 originated from spawning grounds west of the Orkney and Shetland Isles, as opposed to within the Moray Firth. In addition, the anticipated hammer energy of 1,200 kJ and 1,800 kJ required for pile installation at the majority of locations across the Development site will result in decreases in the spatial area of the 90 dB_{ht} noise contours compared to those originally assessed in the ES.

10.3.2 Should the herring spawning surveys completed by BOWL in September 2015 (for which results are not yet available) resemble those of the surveys completed in 2014, BOWL proposes that mitigation for herring will not be required. However, final decisions on mitigation requirements for herring will be agreed with MSS and MS-LOT once the results of the 2015 herring spawning surveys are available.

Mitigation for Cod

10.3.3 Section 8.5 has set out the results of the site specific pre-construction surveys undertaken during February and March 2014 to better determine the distribution of spawning cod in the vicinity of the Development and further contribute to the current scientific knowledge on the spawning of this species in the Moray Firth. Based on the predefined criteria stipulated by MSS, on average seven stations sampled during the survey (~17% of the total) were classified as “spawning areas”.

10.3.4 Currently BOWL requires flexibility pile in February and March 2018 should the 2017 piling programme not be completed on schedule (as described in Section 6.4). Limited piling could therefore potentially overlap with some cod spawning activity within the Moray Firth.

10.3.5 Should piling during the cod spawning period be required, BOWL will discuss with MSS the viability of potential mitigation options in seeking to reduce potential effects on spawning cod during the peak spawning period in February and March.

Piling Mitigation for Atlantic salmon

10.3.6 Mitigation measures for Atlantic salmon are not proposed given that only a small proportion of the Atlantic salmon habitat in the Moray Firth will be affected, and the piling noise will not form a ‘barrier’ to salmon migration (see Section 8.3 and Section 9).

10.3.7 However, in recognition of the paucity of information on the behaviour and biology of adult Atlantic salmon and smolts when they pass through the marine environment of the Moray Firth, it has been agreed with MSS and the ASFB that such uncertainties can best be overcome through strategic research. BOWL is developing a comprehensive monitoring study for Atlantic salmon smolts in consultation with MSS (see Section 11.5).

10.4 Mitigation for Concurrent Piling

10.4.1 There are no plans to pile concurrently during the piling operations process. However, if there is requirement for an additional vessel, BOWL have made a commitment in the ES and SEIS to ensure that these vessels will operate at a maximum separation distance of 5 km, therefore minimising the spatial extent of the area disturbed by subsea noise. Concurrent piling has the potential to also further reduce the time period over which piling occurs.

11 Monitoring

11.1 Introduction

11.1.1 Section 36 consent condition 12c and OfTW Marine License condition 3.2.2.5c set out the requirement for this PS to include:

c. Details of mitigation and monitoring to be employed during piling, as agreed by the Scottish Ministers.

11.1.2 This section provides details of the monitoring measures BOWL will implement in relation to piling operations. Monitoring for fish species is set out in Sections 11.4, 11.5 and 11.6.

11.1.3 The monitoring related to marine mammals is set out under Sections 11.2 and 11.3 and focuses on the following areas:

- Monitoring the noise emitted from the piling operations; and
- Mitigation monitoring for marine mammals.

11.1.4 Reporting requirements are set out under Section 13.

11.2 Underwater Noise Monitoring

11.2.1 Monitoring of underwater noise resulting from piling activities and preliminary vibropiling will be undertaken to address the question of whether received noise levels correspond to those predicted in the acoustic models that underpin the ES assessment and the Piling Mitigation Protocol.

11.2.2 Noise monitoring will be designed to align with the construction MMMP rather than being conducted to simply test emitted noise levels from piling. Specifically, noise monitoring will address the following questions:

- How do predicted source and near-field noise (i.e. less than 1 km) levels vary temporally in relation to changes in hammer energy?
- How do predicted far-field (i.e. greater than 1 km) levels vary spatially?
- How do predicted far-field levels vary through construction, particularly in relation to cumulative noise exposure to harbour seal (with reference to WP 1.3 in the Construction MMMP – see Section 11.4 below).

11.2.3 The measurements would be made using seabed mounted noise recorders, as used by Merchant *et al*. (2014) to monitor ship noise and by MSS in their East Coast Passive Acoustic Monitoring (PAM) array. This would involve a combination of shorter term deployments around the first cluster of turbine sites and lower-resolution longer term deployments (to assess variation in piling and other anthropogenic noise sources through the construction period (to inform WP 1.3: *Harbour Seal Characterisation of Foraging Areas and Responses to Piling* - see Section 11.4 below).

11.2.4 Since the ES was completed, further work has been conducted on the responses of marine mammals to piling noise, for example, the recent studies by Hastie *et al.* (2015) on harbour seal in the Wash. Consequently, predictions using subsea noise modelling to estimate cumulative noise exposure have progressed from the methods applied in the original ES (including the noise propagation model used in the Moray Firth Harbour Seal Framework (Thompson *et al*., 2011a; 2011b)).

11.2.5 Use of measurements to validate acoustic model predictions should focus on benchmarking against the overall conclusions of the original ES, rather than specific modelling elements within them. For example, the Moray Firth Seal Assessment Framework originally used Subacoustech's noise propagation modelling, whereas more recent studies by Hastie *et al*. (2015) have demonstrated that alternative noise propagation models can provide more robust estimates of cumulative noise exposure. Thus, the noise measurements will be used to validate the use of the alternative propagation models that will best test the Seal Assessment Framework rather than the original propagation models used in the ES. Further information will be provided in the PEMP.

11.3 Mitigation Monitoring for Marine Mammals

11.3.1 The S36 Consent and Marine Licence (OfTW) Condition 3.2.1.1b require that BOWL participate in surveys to be carried out in relation to marine mammals as set out in the strategic regional MMMP.

11.3.2 The construction MMMP, which aims to assess the population consequences of constructing the BOWL and MORL Wind Farms will set out two work packages to test the responses of marine mammals to ADDs and piling soft starts as part of a commitment in the proposed Piling Mitigation Protocol described in Section 10.2.

11.3.3 A summary of the key elements of the mitigation monitoring to be provided through the construction MMMP is given below.

WP 3.1: Responses of harbour seal to ADD and piling soft starts

11.3.4 Following discussion with SNH (23rd June, 2015) it was agreed that whilst there is limited opportunity for dedicated work during construction, broader scale tracking work under WP 1.3 (harbour seal responses to piling) may provide opportunistic evidence of responses to ADDs should harbour seal be in nearfield areas during a soft start. Any other focussed work outside the construction area would need to build upon recent MS funded work by Sea Mammal Research Unit (SMRU), most likely through the Offshore Renewables Joint Industry Programme (ORJIP).

11.3.5 Further details will be discussed and agreed through the MFRAG-MM subgroup and provided to MS-LOT / the Licensing Authority as part of the construction MMMP scope, which will also be reported within the BOWL PEMP.

WP 3.2: Responses of harbour porpoise to ADD and piling soft starts

11.3.6 It is proposed that questions that have emerged during the development of the Piling Mitigation Protocol should be addressed under this work package, specifically:

- To what extent are porpoise displaced from piling areas by ADD use prior to soft start, and during soft starts?
- How long does it take porpoise to move back into the piling area during breaks in piling?
- How do levels of response and return times vary in relation to a) habitat quality and b) time since the start of construction?

11.3.7 Studies of the fine-scale (<100m) responses are not considered to be feasible during piling operations because extremely low numbers of animals are expected to be within the 60 m injury zone (see Annex C in Appendix D). This means that sample sizes would be too small to draw robust conclusions about whether or not animals were excluded from these areas.

11.3.8 Monitoring will therefore focus on medium-scale (100 to1000m) responses. If animals can be shown to respond to ADDs at this scale, then it will provide confidence that ADDs also provide protection at finer scales. However, it should be recognised that if no response is identified at this broader scale then it cannot be concluded that there is no response at finer scales.

11.3.9 These medium-scale studies are likely to use seabed mounted data loggers deployed around piling sites. The detailed design of these studies will depend upon the final sequence of construction operations, and agreement from the BOWL Senior Project Manager but will be set out for approval in the PEMP.

11.3.10 In general terms the proposed monitoring will be as follows:

- Two phases of monitoring will be undertaken, each involving focussed studies around a single cluster of turbine sites, with an array of 3 to 4 static acoustic recorders (C-PODs) ~ 500 m from each turbine location, and sampling sites selected to provide

a. a gradient of distances for each piling sequence; and

b. variation in baseline harbour porpoise density (which is assumed to reflect differences in habitat quality);

- Phase 1 of the monitoring will be completed at the beginning of the first piling 'season', and Phase 2 towards the end of the first piling 'season' to allow an exploration of how responses and return times varied in relation to time since the start of construction; and
- The acoustic recording devices will be deployed by a separate vessel 1-2 weeks before the HLV arrives at the chosen turbine locations. Device moorings will be fitted with transponders so that construction vessels can locate devices when working in close proximity. Recovery of the acoustic recording devices will also be made from separate vessels after the HLV leaves the study area.

11.3.11 The final details of the monitoring will be discussed with other members of the MFRAG-MM subgroup and set out for approval in the PEMP.

11.4 Diadromous Fish Monitoring

11.4.1 BOWL will be implementing a pre-construction monitoring programme for Atlantic salmon smolts in 2016 to meet the requirements of the S36 Consent Conditions 27 (PEMP) (specifically Condition 27a5) and 31 (participation in the *'Scottish Atlantic Salmon, Sea Trout and European Eel Monitoring Strategy'*) and the OfTW Marine Licence Conditions 3.2.1.1 (PEMP) (specifically Condition 3.2.1.1a1) and 3.2.1.3 (participation in the '*Scottish Atlantic Salmon, Sea Trout and European Eel Monitoring* Strategy').

11.4.2 The monitoring will be designed to provide information on the biology and behaviour of smolts when moving through the marine environment of the Moray Firth. Details of this monitoring will be provided, for approval, in the PEMP.

11.5 Herring Monitoring

11.5.1 Pre-construction herring spawning surveys were completed in August and September 2014. As set out in Section 8.4 above, the surveys indicate that herring spawn to the west of Orkney/Shetland and are therefore unlikely to be affected by the noise emissions resulting from piling. Repeat herring spawning surveys were completed in September 2015, however the results are not yet available. Should the results of the 2015 surveys resemble those of the 2014 surveys, further during and post-construction monitoring will not be required. Monitoring requirements will be discussed with MSS and MS-LOT following review of the 2015 survey results.

11.5.2 Further details in relation herring larval surveys (pre-construction) will be provided in the PEMP (as required by the S36 Consent Condition 27 and the OfTW Marine Licence

Condition 3.2.1.1).

11.6 Cod Monitoring

11.6.1 As required by S36 Conditions 27 (PEMP) and 35 (pre and post-construction monitoring for cod), BOWL completed pre-construction cod spawning surveys in February and March 2014 as described in Section 8.5.

11.6.2 BOWL propose to undertake a post-construction cod survey in the first February and March, occurring no earlier than 12 months following the Final Commissioning of the Wind Farm. Further details in relation cod surveys (post-construction) will be provided in the PEMP.

11.6.3 In addition, in the event that piling operations are required during February and March (the cod spawning season), there may be an option for BOWL to carry out cod spawning surveys, the objective being to provide data on whether piling activity has any noise induced effects on cod spawning behaviour. This will be subject to further discussions with MS-LOT / the Licensing Authority and in consultation with MSS.

12 Licences and Legal Requirements

12.1.1 All species of cetaceans[2] are listed in Schedule 2 of the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland) (hereafter 'the Habitats Regulations') as European Protected Species (EPS), and are protected by law (Regulations 39(1) and 39(2) of the Habitats Regulations) from activities with the potential to deliberately or recklessly kill, injure or disturb these species.

12.1.2 Cetaceans are afforded strict protection in Scottish inshore waters at all times, regardless of the circumstances of the mammal at the time of the disturbance in question. The Marine Scotland (2014) guidance '*The Protection of Marine European Protected Species from Injury and Disturbance: Guidance for Scottish Inshore Waters'* considers the activities that have the potential to result in a disturbance; these activities include piling.

12.1.3 An EPS licence will be required to undertake the piling operations to install foundations during the construction phase of the Development, as well as use of ADDs. An EPS licence application to Marine Scotland will be made by BOWL and will be submitted with an EPS Licence Application Supporting Document.

12.1.4 The EPS licence application process will adopt a risk-based approach and will take into consideration the information and mitigation presented within this PS and will follow the guidance outlined in '*The Protection of Marine European Protected Species from Injury and Disturbance Guidance for Scottish Inshore Waters'* (Marine Scotland, 2014).

[2] Pinnipeds (i.e., seals) are not listed in Schedule 2 and are not EPS and, as such, considerations with respect to EPS licensing are only applicable to cetaceans.

13 Reporting and Auditing

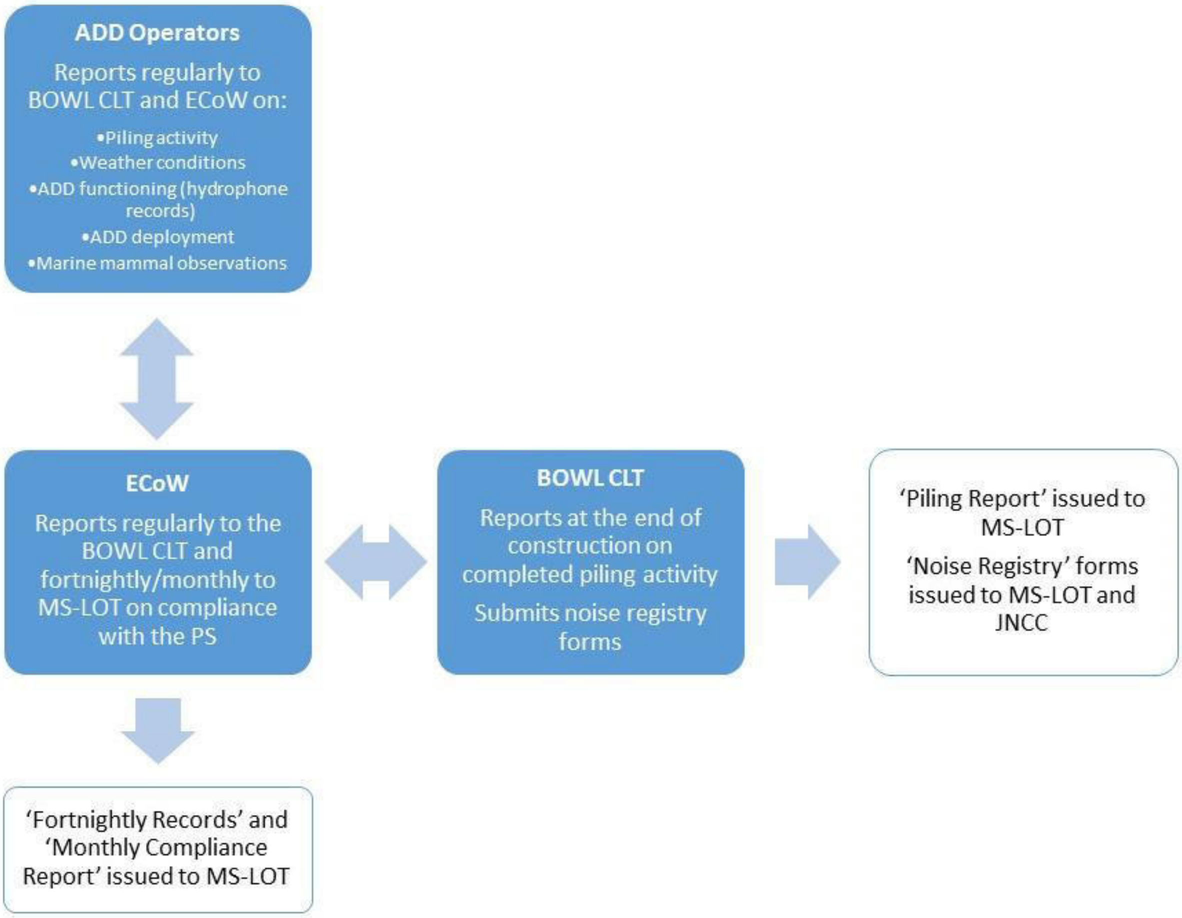
13.1 Overview

13.1.1 Data gathered during piling operations will be used and reported on in a number of ways, in line with the requirements of relevant S36 Consent and Marine Licence conditions. Figure 13.1 below sets out how data gathered on piling activity and mitigation deployment will be used and identifies the reporting responsibilities of the ADD Operators, the BOWL CLT and the ECoW in relation to the Piling Strategy. It indicates the following:

- The ADD Operator on shift will gather information in the field relating to piling activity, including ADD functionality and deployment. This information will be shared regularly with the ECoW during the piling season, and also provided to the BOWL CLT.
- The BOWL CLT, will collate information provided by the ADD Operators and report to MS-LOT on piling activity and mitigation deployment. The BOWL CLT and SHL will be responsible for Noise Registry reporting to MS-LOT and the JNCC.
- The ECoW will collate information provided by the ADD Operators and use it to audit compliance with the PS. The ECoW will provide fortnightly Piling Strategy compliance reports to MS-LOT during construction (the frequency of Piling Strategy compliance reporting will be reviewed with MS-LOT following the initial period of piling activity).

13.1.2 Further detail on each of the reporting streams shown in Figure 13.1 is provided in the text below.

Figure 13.1 – PS reporting streams and responsibilities (key lines of communication are depicted by arrows, reporting responsibilities are shown in blue shaded boxes, key report outputs are shown in white, outlined boxes)



13.2 Field Records during Piling

13.2.1 The ADD Operators will report on piling operations and mitigation deployment during piling operations. Reports will include, but not be limited to the following:

- Location and piling activity;
- Weather conditions during ADD deployment, including visibility.
- Start and end times of soft start piling and impact piling;
- Details of soft-start procedures and hammer energy employed at each piling location, including the duration of full-power piling;
- Confirmation that the ADD has been tested and is functioning as per specifications (Appendix C), with auditable audio files to confirm effective functioning (to be submitted as hydrophone files);
- Time and duration of ADD deployment prior to piling events; and

- Observations of marine mammals during the testing and deployment of the ADD.

13.2.2 The ADD Operators will collate data regarding the overall duration of piling and the hammer energy used during the piling operations in order to verify that the correct procedures for soft-start have been carried out. This will be in the form of individual hammer energy per blow, and frequency of blows during the initial soft start period where the piles will be struck approximately 5 to 6 times at an approximate 10 second interval, followed by average hammer energy over a 250mm pile embedment during the remaining piling period. Reports collated by the ADD Operators will be produced in pdf format to form a database archive of all records that will be sent to the ECoW and the BOWL CLT.

13.2.3 The information gathered by the ADD Operators will be shared with the ECoW on a regular basis during piling operations. It will be used by the ECoW to monitor and report on compliance with the PS (see Section 13.6).

13.2.4 The information will also be issued to the BOWL CLT, who will collate and issue relevant data to MS-LOT and JNCC (see Sections 13.5 and 13.6).

13.3 Compliance Reporting

13.3.1 The ECoW will use the data provided by the ADD Operators to audit compliance with the PS. The ECoW will report on Piling Strategy compliance to the BOWL CLT on a frequent basis and to MS-LOT on a fortnightly basis (reporting frequency to be reviewed with MS-LOT following the initial period of piling activity). Fortnightly reporting to MS-LOT will include provision of marine mammal observation records and hydrophone files. These same records will also be provided to the University of Aberdeen as an anecdotal log of marine mammal observations to complement the dedicated monitoring of responses to ADD use as described in the mitigation monitoring for marine mammals (Section 11.4 of the main document).

13.3.2 This fortnightly reporting will be in addition to the monthly compliance reporting requirements detailed in the EMP.

13.3.3 The ECoW will similarly audit and report on compliance with other Consent Plans, including the PEMP, which are of particular relevance to this PS.

13.4 Noise Registry Reporting

13.4.1 Under the Marine Strategy Regulations (2010), there is a requirement to monitor loud, low to mid frequency (10 Hz to 10 kHz) impulsive noise such as that produced by piling.

13.4.2 This is reflected in the Project consents through the requirement to complete a Noise Reduction Registry Form before, during and after the completion of the construction works.

13.4.3 Prior to the works, the Wind Farm and OfTW Marine Licences Conditions 3.2.1.5 and 3.2.2.17 respectively require that

The Licensee must, in the event that pile foundations are to be used, submit the appropriate completed noise reduction registry form to the Licensing Authority and the Joint Nature Conservation Committee ("JNCC"), stating the proposed date(s), location(s) and nature of the piling activities under authority of this licence.

13.4.4 BOWL CLT will complete and submit the 'Initial Registration Form', available from the Marine Scotland website (http://www.gov.scot/Resource/0045/00458845.xls), prior to construction outlining the proposed date(s), location(s) and nature of the piling activities.

13.4.5 During construction, the Wind Farm and OfTW Marine Licences Conditions 3.2.2.6 and 3.2.3.9 respectively require that:

The Licensee must, in the event that pile foundations are to be used, and piling is to be carried out for more than 10 consecutive days, submit at quarterly intervals, the appropriate completed noise reduction registry form to the Licensing Authority and the JNCC, stating the date(s), location(s) and nature of such activities under authority of this licence.

13.4.6 SHL, on behalf of BOWL, will complete and a 'Closeout Form (Wind)' available from the Marine Scotland website (http://www.gov.scot/Resource/0045/00458845.xls), at quarterly intervals, stating the actual date(s), location(s) and nature of such activities (including hammer energies).

13.4.7 Upon completion of the works, the Wind Farm and OfTW Marine Licences Conditions 3.2.3.5 and 3.2.4.7 respectively require that:

The Licensee must, in the event that pile foundations were used, submit the appropriate completed noise reduction registry form to the Licensing Authority and the JNCC, within 12 weeks of Completion of the Works, stating the actual date(s), location(s) and nature of piling activities carried out under authority of this licence.

13.4.8 BOWL CLT will submit a final close out form setting out the final dates, locations and nature of the piling activities completed.

13.4.9 Once completed, all forms will need to be renamed with the first five digits of the licence number and the date, and returned, via email, to MS-LOT / the Licensing Authority and JNCC.

13.5 Final Piling Report

13.5.1 The BOWL CLT will submit a final 'Piling Report' to MS-LOT on the completion of construction works. The report will be a compilation of the field records gathered by the ADD Operators (see Section 13.2). It will include a piling profile for each pile installed, and include details of soft-start procedures, maximum hammer energy used and the duration of impact piling at each pile location. This will enable comparison against this PS. It will also include records of ADD testing and deployment.

14 References

Atkins (2015) *Beatrice Offshore Wind Farm CMP Preliminary Pile Driveability Study*.

Baxter, J.M., Boyd, I.L., Cox, M., Donald, A.E., Malcolm, S.J., Miles, H., Miller, B., Moffat, C.F. (2011). Scotland's Marine Atlas: Information for the national marine plan. Marine Scotland, Edinburgh.

BOWL (2012a) Beatrice Offshore Wind Farm Environmental Statement.

BOWL (2012b) Report to Inform a Habitats Regulation Assessment. Supporting documentation for the HRA for Beatrice Offshore Wind Farm.

BOWL (2013) Beatrice Offshore Wind Farm Environmental Statement Addendum; May 2013

BOWL. (2014a) Pre-construction Baseline Herring Larval Survey- Technical Report, December 2014. LF000005-REP-345.

BOWL (2014b) Pre-construction Baseline Cod Spawning Survey – Technical Report, February 2015. LF000005-REP-094.

Bailey, H., Hammond, P.S. & Paul M. Thompson (2014). *Modelling harbour seal habitat by combining data from multiple tracking systems.* Journal of Experimental Marine Biology and Ecology, 450: 30-39

Bailey, H. and Thompson, P.M (2011). *Technical report on harbour seal telemetry and habitat model*. SMRU Ltd/University of Aberdeen report to MORL and BOWL.

Brandt M.J., Höschle C., Diederichs A., Betke K., Matuschek R., Witte S., Nehls G. 2013 *Far-reaching effects of a seal scarer on harbour porpoises*, *Phocoena phocoena*. Aquat Conserv Mar Freshwater Ecosys 23(2), 222-232.

Brookes, K.L., Bailey, H. & Thompson, P.M. (2013). *Predictions from harbor porpoise habitat association models are confirmed by long-term passive acoustic monitoring*. J. Acoust. Soc. Am., 134: 2523-2533

Brown, R.F. and Mate, B.R. (1983). Abundance, movements and feeding habits of harbour seals, *Phoca vitulina*, at Netarts and Tillamook Bays, Oregon. *Fishery Bulletin*, 81, 291-301.

Cheney, B., Corkrey, R., Quick, N.J., Janik, V.M., Islas-Villanueva, V., Hammond, P.S. and Thompson, P.M. (2012*) Site Condition Monitoring of bottlenose dolphins within the Moray Firth Special Area of Conservation: 2008 - 2010*. Scottish Natural Heritage Commissioned Report No.512.

Cheney, B., Thompson, P.M., Ingram, S.N., Hammond, P.S., Stevick, P.T., Durban, J.W., Culloch, R.M., Elwen, S.H., Mandleberg, L., Janik, V., Quick, N.J., Villanueva, V.I., Robinson, K.P., Costa, M., Eisfeld, S.M., Walters, A., Phillips, C., Weir, C.R., Evans, P.G.H, Anderwald, P., Reid, R.J., Reid, J.B. and Wilson, B. (2013). Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins (*Tursiops truncatus*) in Scottish Waters. 2012 *Marine Mammal Review* 43(1): 71–88.

Coull., K.A., Johnstone, R. and Rogers, S.I., (1998) *Fisheries Sensitivity Maps in British Waters*. Published and distributed by UKOOA Ltd.

Ellis, J.R., Milligan, S., Readdy, L., South, A., Taylor, N. and Brown, M., (2010). *Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones).*

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012) *Spawning and Nursery*

Grounds of Selected Fish Species in UK Waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

Finneran, J. J., Carder, D. A. and Ridgway, S. H. (2002). Low-frequency acoustic pressure, velocity, and intensity thresholds in a bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas*). *J. Acoust. Soc. Am*., 111, pp. 3256-3265.

Finneran, J. J., Carder, D. A., Schlundt, C. E. and Ridgway, S. H. (2005) Temporary threshold shift (TTS) in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. *Journal of the Acoustical Society of America*, 118, 2696-2705.

Fugro Geoconsulting Ltd. (2014). G*eotechnical Report, Field Data, Beatrice Offshore Wind Farm, Rev. 02.* J11053-1.

Gibb, I.M., Wright, P.J and Campbell, R. (2008) *Identifying critical spawning and nursery areas for North Sea cod; improving the basis for cod management.* Fisheries Research Services. Scottish Industry/Science Partnership (SISP). Report No 03/08.

Graham, I.M., Cheney, B., Hewitt, R.C., Hastie, G.D. and Thompson, P.M. (2015) *Strategic Regional Pre-Construction Marine Mammal Monitoring Programme Annual Report 2015.* 6 May 2015.

Guerin, A.J., Jackson, A.C., Bowyer, P.A., Youngson, A.F. (2014). 'Hydrodynamic models to understand salmon migration in Scotland.' The Crown Estate, 116 pages. ISBN: 978-1-906410-52-0.

Hastie, G.D., Russell, D.J.F, McConnell, B., Moss, S., Thompson, D., Janik, V.M. (2015) Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage. *Journal of Applied Ecology* 52, 631-640.

Hastie, G.D., Wilson, B., Wilson, L.J., Parsons, K.M. and Thompson, P.M. (2004). Functional mechanisms underlying cetacean distribution patterns: hotspots for bottlenose dolphins are linked to foraging. *Marine Biology* 144, 397-403.

Heath, M., Leaver, M., Matthews, A., and Nicoll, N. (1989). Dispersion and feeding of larval herring (*Clupea harengus* L.) in the Moray Firth during September 1985. Estuar. Coast. Shelf Sci. Vol. 28. 549-566.

Henderson, D. and Hamernik, R.P. (1986). Impulse Noise: Critical Review. *J. Acoust. Soc. Am*. 80: 569-584.

Jeffries, S. (1986) *Seasonal movements and population trends of harbor seals (Phoca vitulina richardsi) in the Columbia River and adjacent waters of Washington and Oregon: 1976–1982*. Marine Mammal Commission, Final Report: Contract No. pp. MM2079357–5.

Joint Nature Conservation Committee (JNCC) (2010) *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise.* August 2010.

Joint Nature Conservation Committee (JNCC), Natural England and Countryside Council for Wales (CCW) (2010). *The protection of marine European Protected Species from injury and disturbance – Draft guidance for the marine area in England and Wales and the UK offshore marine area.* March 2010.

Kastak, D., Schusterman, R. J., Southall, B. L., and Reichmuth, C. J. (1999). Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. *J. Acoust. Soc. Am*. 106, 1142–1148.

Kastak, D., Southall, B., Schusterman, R., and Reichmuth-Kastak, C. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. *J. Acoust. Soc. Am*. 118, 3154–3163.

Koschinski, D. B. S., and Lüdemann, D. B. K. (2013). *Development of Noise Mitigation Measures in Offshore Wind Farm Construction*. Commissioned by the Federal Agency for Nature Conservation.

Lockyer, C. 1995. Investigation of aspects of the life history of the harbour porpoise, *Phocoena phocoena*, in British waters. In Special Issue, 16: Biology of phocoenids, A. Bjørge and G. P. Donovan (eds). Cambridge: International Whaling Commission, 189–197.

Lucke K., Siebert, U., Lepper, P.A. and Blanchet, M.A. (2009). *Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli*. J Acoust Soc Am 125, :4060–4070.

OSPAR (2014). *Inventory of measures to mitigate the emission and environmental impact of underwater noise*. OSPAR Convention Biodiversity Series, OSPAR Intersessional Correspondence Group Underwater Noise.

Marine Scotland (2014). *The protection of Marine European Protected Species from injury and disturbance Guidance for Scottish Inshore Waters*. Prepared by Scottish Government in partnership with Scottish Natural Heritage. March 2014

Merchant, N. D., Pirotta, E., Barton, T. R., and Thompson, P. M. (2014). Monitoring ship noise to assess the impact of coastal developments on marine mammals. *Marine Pollution Bulletin*, 78(1-2):85–95.

National Oceanic and Atmospheric Administration (NOAA) (2013). *Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals*. Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts. Draft: 23 December 2013.

Nedwell, J.R., Turnpenny, A.W.H., Lovell, J., Parvin, S.J., Workman, R., Spinks, J.A.L., and Howell, D. (2007) *A validation of the dBht as a measure of the behavioural and auditory effects of underwater noise*. Subacoustech Report Reference 534R1231, Publish by Department for Business, Enterprise and Regulatory Reform.

Nichols, J. (1999). Saving North Sea Herring. *Based on an article first published in Fishing News 12th February 1999.* Available from: http://www.cefas.defra.gov.uk/publications-and-data/miscellaneous-publications/saving-north-sea-herring.aspx.

Parvin S J, Nedwell J R, Harland E. (2007). *Lethal and physical injury of marine mammals, and requirements for Passive Acoustic Monitoring*. Subacoustech Report Reference: 565R0212, April 2007, To UK Government Department of Business, Enterprise and Regulatory Reform, 1 Victoria Street, London, SW1H 0ET, 2007.

Robinson, K.P., Baumgartner, N., Eisfeld, S.M., Clark, N.M., Culloch, R.M., Haskins, G.N., Zapponi, L., Whaley, A.R., Weare, J.S. and Tetley, M.J. (2007). The summer distribution and occurrence of cetaceans in the coastal waters of the outer southern Moray Firth in northeast Scotland (UK). *Lutra* 50(11): 13-26.

Saleem, Z. (2011). *Alternatives and modifications of Monopile foundation or its installation technique for noise mitigation*. Report by Delft University of Technology for Stichting De Noordzee (the North Sea Foundation).

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr., C. R., Kastak, David, Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., and Tyack, P. L. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific

Recommendations. *Aquatic Mammals*, 33 (4), pp. 411-509.

Turrell, W.R., Henderson E.W., Slesser, G. (1990). Residual transport within the Fair Isle Current observed during the Autumn Circulation Experiment (ACE). Continental Shelf Research 10: 521–543.

Thompson, P.M. (2015). A *strategic regional Marine Mammal Monitoring Programme for assessing the population consequences of constructing the BOWL and MORL wind farm developments.* Rev 5, 20th May, 2015.

Thompson, P.M., Brookes, K.L. & Cordes, L.S. (2015). *Integrating passive acoustic and visual data to model spatial patterns of occurrence in coastal dolphins.* ICES J. Mar. Sci.72 (2): 651-660

Thompson, P. and Brookes, K. (2011). *Technical report on pre-consent marine mammal data gathering at the MORL and BOWL wind farm sites*. University of Aberdeen report to MORL and BOWL.

Thompson, P.M. and Hastie, G.D. (2011). *Proposed revision of noise exposure criteria for auditory injury in pinnipeds*. University of Aberdeen. 2nd Draft, 11th October 2011.

Thompson, P., Hastie, G., Nedwell, J., Barham, R., Brooker, A., Brookes, K., Cordes, L., Bailey, H., and McLean, N. (2011a). *Framework for assessing the impacts of pile driving noise from offshore wind farm construction on Moray Firth harbour seal populations*. Report to support two offshore wind farms applications in the Moray Firth, on behalf of BOWL and MORL.

Thompson, P., Hastie, G., Nedwell, J., Barham, R., Brooker, A., Brookes, K., Cordes, L., Bailey, H., and McLean, N. (2011b) Framework for assessing the impacts of pile driving noise from offshore wind farm construction on a harbour seal population. *Environmental Impact Assessment Review* 43 (2013) 73–85.

Thompson, P.M. (1993). *Harbour seal movement patterns.* Symposium of the Zoological Society of London, 66: 225-239

UKMMAS. (2010). Charting Progress 2 Feeder Report: Ocean Processes (Ed. Huthnance, J). Produced by Department for Environment Food and Rural Affairs on behalf of the United Kingdom Marine Monitoring and Assessment Strategy. http://chartingprogress.defra.gov.uk/ocean-processes-feeder-report. 279 pp.

van Beest, F.M, Nabe-Nielsen, J., Carstensen, J., Teilmann, J. and Tougaard, J. (2015). *Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS): Status report on model development*. Aarhus University, DCE – Danish Centre for Environment and Energy, 43 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 140 http://dce2.au.dk/pub/SR140.pdf.

Wilson, B., Thompson, P.M. & Hammond, P.S. (1997) *Habitat use by bottlenose dolphins: seasonal distribution and stratified movement patterns in the Moray Firth, Scotland*. Journal of Applied Ecology, 34: 1365-1374

Wright, P.J., Gibb, F.M., Gibb, I.M., Heath, M. R. and McLay, H.A. (2003) *North Sea cod spawning grounds*. Fisheries Research Services Internal Report No 17/03.

Wyatt, R. (2008). Report by Seiche Measurements *Review of Existing Data on Underwater Sounds Produced by the Oil and Gas Industry-Issue 1*Ltd., Great Torrington, to Joint Industry Programme on Sound and Marine Life, Seiche Measurements Limited Ref–S186.

[Page left intentionally blank]

Appendix A – ES/SEIS Commitments

Details of Beatrice ES/SEIS Commitment	**Summary of Status**	**Reference to relevant Section of this PS**
Piling protocol to be adopted in line with the JNCC guidelines (JNCC, 2010), including the implementation of a 500 m 'mitigation zone' to be monitored by dedicated Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM) operatives during a pre-piling search of no less than 30 minutes.	BOWL have developed an overarching Piling Mitigation Protocol in conjunction with Moray Offshore Renewables Limited (MORL) and the University of Aberdeen (see Appendix D) involving the deployment of Acoustic Deterrent Devices (ADDs), as an alternative to the current JNCC protocol (where MMOs and PAM are recommended), which has been presented to and agreed with key stakeholders (MS-LOT, Marine Scotland Science (MSS), JNCC and SNH). The details of the Piling Mitigation Protocol proposed for the Development are contained within this PS.	Section 10.2 and Appendix D.
A soft-start procedure of no less than 20 minutes, to be implemented prior to piling with the force of piling gradually ramping up thereafter.	A soft-start, totalling no less than 20 minutes, has been proposed as part of the site-specific Piling Mitigation Protocol outlined in Section 10.2, the detail of which has been discussed and agreed with key stakeholders as described in Section 4.	Summarised in Section 10.2 and Appendix D.
Maximum vessel separation of 5 km during concurrent piling operations.	Simultaneous piling operations are currently not envisaged, however, should this be considered necessary, BOWL will abide by the maximum vessel separation commitment.	Section 10.4
Development of a PS to minimise effects on agreed species throughout the construction period.	Following detailed geotechnical investigations undertaken post-consent and a review of the sensitivities of key species, BOWL have developed a PS, the details of which are provided in this document.	Section 7 and Section 8.
BOWL will look to investigate further the application of a number of different mitigation tools to reduce underwater noise as trialled by ESRa (Evaluation	BOWL have continued to monitor the industry and investigate mitigation measures to reduce as far as practicable the effects of construction noise on marine mammals. BOWL considers the Piling Mitigation Protocol proposed in this	Summarised in Section 11 and Appendix D.

Details of Beatrice ES/SEIS Commitment	Summary of Status	Reference to relevant Section of this PS
of Systems for Ramming) in Summer 2011 if these tools prove to be viable commercially and achieve sufficient sound reduction such that effects on marine mammals would be significantly reduced.	PS to be the most suitable mitigation option for minimising the risk of instantaneous death and injury to marine mammals.	
Development and implementation of a comprehensive MMMP.	BOWL have developed pre- and during construction MMMPs in conjunction with MORL and the University of Aberdeen comprising a suite of studies aimed at understanding the effects of piling on marine mammal species, with specific focus on bottlenose dolphin and harbour seal as the two key species listed in the S36 Consent (see Section 1.2), as well as harbour porpoise. The MMMP is aligned with the Piling Mitigation Protocol for the Development (Appendix D) in order to test the response of marine mammals to the proposed mitigation.	Appendix D and summarised in Section 11.
BOWL will work with key stakeholders and MS to identify any future monitoring programmes considered necessary for fish and shellfish.	BOWL completed pre-construction cod and herring spawning surveys in 2014 as required by the S36 Consent (Conditions 34 and 35). BOWL is developing a diadromous fish monitoring programme to increase the knowledge base of salmon smolts in the Moray Firth as required by the S36 Consent (Conditions 27 and 31). Monitoring programmes were not deemed necessary for shellfish species as their sensitivity to noise was assessed as low in the ES, and the predicted magnitude of effect was assessed as negligible (BOWL, 2012a). There are no consent conditions that require monitoring for shellfish species.	Section 8.4, 8.5 and 8.6 and Section 11.5 – 11.7

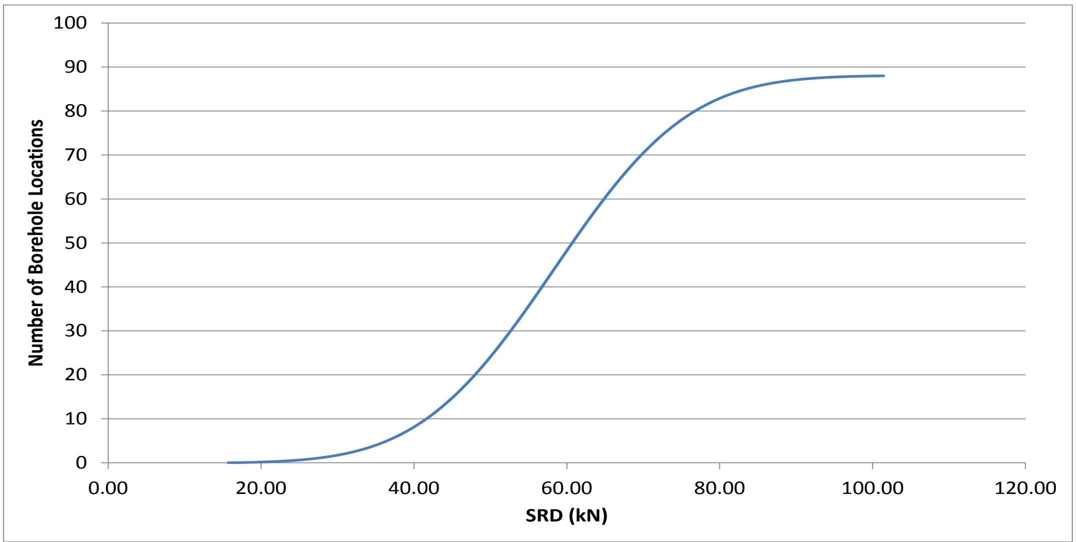
Appendix B – Ground Information Benchmarking Procedure

Input data: the original pile driveability study was undertaken for each of the 27 boreholes on the basis of a 1.8 m diameter pile with loads derived from a 6 MW Siemens turbine. The design was refined and subsequently the pile driveability study re-done for 12 boreholes which were representative of the varying conditions across the site on the basis of a 2.2 m diameter pile with loads derived from a 7MW Siemens turbine.

Benchmarking (12 to 27 borehole locations): the relative increase in piling resistance was calculated for the 12 subsamples from the original pile driveability study (1.8 m/6MW) to the revised pile driveability study (2.2 m/7MW). The average increase was then used as a multiplication factor to determine the driving resistance at the remaining 15 locations. Since the 12 selected locations were representative of the conditions across the site, the average increase in driving resistance would indicate the increase for the remaining locations. Benchmarking was only applied for the locations requiring a 1,200 kJ hammer since for all locations requiring a greater hammer energy (1,800 kJ or above) in the original pile driveability study, the pile driveability was re-calculated, therefore allowing a more accurate assessment where piling may be problematic.

Calculation of hammer energy (27 to 88 borehole locations): To calculate the pile driveability for all the 88 borehole locations from the information available from the above steps, a probability density function (pdf) was derived from a histogram of SRD frequencies using the benchmarked data to determine the probability that the Soil Resistance to Driving (SRD) fell within the given range. The pdf was subsequently used to calculate a cumulative distribution of driving resistances across the 88 WTG/OTM locations (Figure B1). The upper bound resistance for a 1,200 kJ hammer is an SRD of 71 kilonewtons (kN), a range of 71 to 80 kN denotes a 1,800 kJ hammer and greater than 80 kN would require a 2,300 kJ hammer. In this way it was possible to predict the hammer energies required across the Wind Farm site.

Figure B1 - Cumulative distribution of piling resistances (SRD) at the BOWL site.



Appendix C – ADD Deployment Protocol

C1.1 This ADD Deployment Protocol provides a detailed specification of how the ADD will be deployed and monitored to ensure compliance with the Piling Mitigation Protocol (Appendix D). This procedural document sets out the following information:

- Details on the Lofitech ADD device with technical specifications;
- Role of ADD operator, including training requirements and experience;
- Task plan to illustrate how mitigation will be carried out through communication with the offshore Operations Manager. This includes a flow chart setting out the activities and decision points prior to commencing the piling soft start;
- Method for testing that the ADD device is functioning effectively; and
- Location of deployment on-board the HLV.

1. ADD Technical Specification and Depth of Deployment

C1.2 The device selected for carrying out the Piling Mitigation Protocol is the Lofitech Seal Scarer (Lofitech AS, Leknes, Norway). A single Lofitech device deployed from the piling vessel will provide sufficient noise levels to deter marine mammals from the 60 m injury zone and beyond (see Appendix D).

C1.3 This device consists of a control unit and transducer (Figure C1). The control unit will be powered by mains if possible, although it also works effectively with a rechargeable Auto-Marin 12V battery with 90 – 120 Ah. The control unit contains a pulse generator and an amplifier and transmits random bursts of audio frequency signals to the transducer, where they are converted into intense sound. The frequencies are randomised in order to avoid acclimatisation by marine mammals but the manufacturers' specifications cite these as typically between 10 to 20 kHz with an output source level of 191 dB re 1 μPa.

Figure C1. Complete Lofitech system showing control box and transducer

C1.4 The ADD will be deployed by the ADD Operator on shift (role as described in Section 3) from the HLV in order to be close to the source and therefore the centre of the injury zone. The Lofitech control unit is housed in a waterproof box (Figure C2) and is connected to the transducer via a 25 m long cable. Depending on where the control unit is located, and the length of cable required for deployment, there is also the option to extend the cable using a waterproof connector, to 100 m. The length of the cable required will be determined *in situ* depending on the water depth such that the transducer is well below the maximum draft of the vessel (to ensure 360^0 coverage), and at a depth approximately mid-way between the draft of the vessel and the seabed. Deployment below 15 m will avoid interference by surface water noise. Water depths within the BOWL developable area range between 36 and 55 m. Therefore, with a maximum draft of 9 m, based on the HLV *Stanislav Yudin* which is the most likely HLV to be selected to install the piles, the expected deployment depth would be approximately 23 m to 32 m. The most suitable depth of deployment will be agreed with MS-LOT following discussion through the MFRAG-MM subgroup, once the details of the HLV have been confirmed.

C1.5 A change to the proposed Lofitech ADD device will be communicated and agreed with Marine Scotland after consultation with the relevant statutory consultees and following the process in Figure 5.1.

Figure C2. Lofitech control unit housed in a waterproof box.

2. Effectiveness of the Lofitech Device

C1.6 The effectiveness of the Lofitech device has been demonstrated for both seals and harbour porpoise. For example, the Lofitech device significantly reduced the proportion of predation from both grey and harbour seals at a wild net salmon fishery (Harris *et al* 2014). More recently, the Lofitech device has been used in trials undertaken through the Scottish Government funded Marine Mammal Scientific Support Research Programme MMSS/001/11. Harbour seals were fitted with high resolution GPS tags in Kyle Rhea in May 2013 and a series of Controlled Exposure Experiments (CEE) carried out to test the efficacy of the Lofitech Seal Scarer in deterring seals. Initial analysis suggests that all seals demonstrated aversive responses to the Lofitech ADD signals in all trials at initial ranges of 1km or less (SMRU, 2014). Further trials were subsequently carried out in the Moray Firth over a longer period in 2014. These trials further substantiated the result that aversive responses of harbour seals to the Lofitech were out to 1 km or greater (Gordon *et al*., 2015).

C1.7 Similar aversive responses have been demonstrated for cetaceans. In one of the most comprehensive trials of acoustic deterrents for mitigation, Brandt *et al*., (2013a) demonstrated that harbour porpoise were effectively deterred at distances of 750 m and beyond (up to 7.5 km) during ADD deployment at a German offshore wind farm, albeit with the mean reduction in porpoise activity decreasing with greater distances from the source, which would be expected. In a second study, Brandt *et al*., (2013b) showed that sightings rates of harbour porpoise at a Danish offshore wind farm fell from 31 animals per 4 hour period out to 1 km, to just 0.4 animals per 4 hours when the ADD was deployed.

3. Role and training of ADD operator

C1.8 Two ADD Operators, appointed by BOWL, will be responsible for deployment, maintenance and operation of the ADD, including spare equipment, in relation to all piling activities. Two ADD Operators are required to work in shifts since the piling activities are scheduled to take place over a 24 hour period. The ADD Operators will be trained to JNCC standards as Marine Mammal Observers (MMOs) (by a JNCC approved course provider.). The ADD Operators will also be trained Passive Acoustic Monitoring (PAM) operators with training provided by a recognised organisation. The ADD Operators will have an appropriate level of field experience, including, where possible, experience of offshore piling operations for wind farms and/or subsea infrastructure. BOWL will inform MS-LOT / the Licensing Authority and the Statutory Nature Conservation Bodies (SNCBs) on the appointment the ADD Operators.

C1.9 The ADD Operator on shift will liaise with the SHL Offshore Manager (role defined at paragraph 3.1.12 of the main document) following a pre-determined “task plan” described below. Communication between the ADD Operator on shift and SHL Offshore Manager will be via handheld radio to ensure that immediate action can be taken at each stage of the task plan. Any problems can also be communicated in this way so that a decision can be made as to the appropriate course of action. For example, malfunctioning of the ADD device would be immediately relayed via radio to the SHL Offshore Manager to ensure that piling is delayed whilst the back-up system is put into place.

C1.10 A list of tasks to be undertaken by the ADD Operator include, but is not limited to:

- Preparation and update of risk assessment for ADD and hydrophone deployment in collaboration with SHL vessel personnel ;
- Provide *in situ* training to vessel personnel to assist in mitigation procedure;
- Maintain, test and operate ADD devices, including spares;
- Maintain, test and operate hydrophone devices to test the ADD is functioning according to its specifications;
- Keep an inventory of spares and advise on any required repairs necessary to ADD and hydrophone devices including back-ups;
- Deploy, test and monitor ADD as per the task plan set out in Figure D3 below;
- Liaise and communicate with the SHL Offshore Manager as required by the task plan below to ensure compliance with the mitigation procedure;
- Instruct vessel personnel during mitigation procedure to ensure smooth running of task;
- Update database at the end of each shift with field records including storage/back-up of hydrophone files;
- Maintain records of marine mammal observations and hydrophone files, and provide reports to the ECoW at regular intervals to ensure compliance

and to provide the necessary data for the fortnightly Piling Strategy compliance reporting from the ECoW to MS-LOT.

4. Testing ADD Functioning

C1.11 The ADD Operator will ensure that the ADD device and spares are functioning correctly before the HLV leaves port. If practical, and in agreement with the Offshore Manager, testing could also be achieved through an initial deploy and test from the vessel, whilst docked. On site, the ADD device will be re-tested prior to the start of the mitigation sequence as specified in the Task Plan (Figure C4).

C1.12 Functioning of the ADD device will be tested using a separately deployed hydrophone (also known as a PAM system). The specification of a typical hydrophone device is presented in the box below. As described in the Task Plan, the ADD Operator will deploy the hydrophone before the ADD device so that a baseline is established prior to switching on the ADD device. Once the hydrophone is in place the ADD Operator will switch on the ADD device at the control unit and monitor the readings of the device at the computer interface.

Specification of a typical hydrophone unit (Seiche)

Mechanical Information

- Length: 100m
- Depth Rating: 100m (not connector)
- Diameter: 12mm over cable, 32mm over mouldings, 30mm over connectors
- Weight : 17kg
- Connector: Amphenol 4 pin

Hydrophone elements

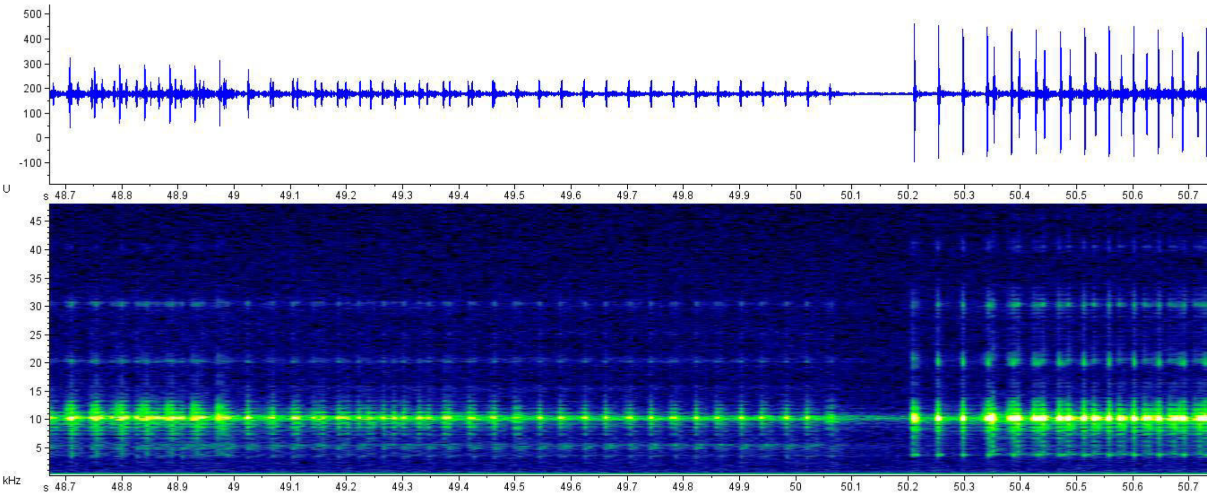
- H1: Sphere Wide band, 20 Hz to 150 kHz (3dB points)
- Depth Capability: 100m

Interface unit outputs

- Wide band channel sensitivity -166dB re 1V/μPa
- Low frequency channel sensitivity -157dB re 1V/μPa

C1.13 Typically, PAMGuard is the software used for real time readings from a hydrophone. The readings from the hydrophone deciphered by the PAMGuard software are illustrated in Figure C3. The PAMGuard system shows a spectrogram (frequency over time) plot of the sound, and allows the operator to listen in real time. This will provide an indication of amplitude but it is uncalibrated.

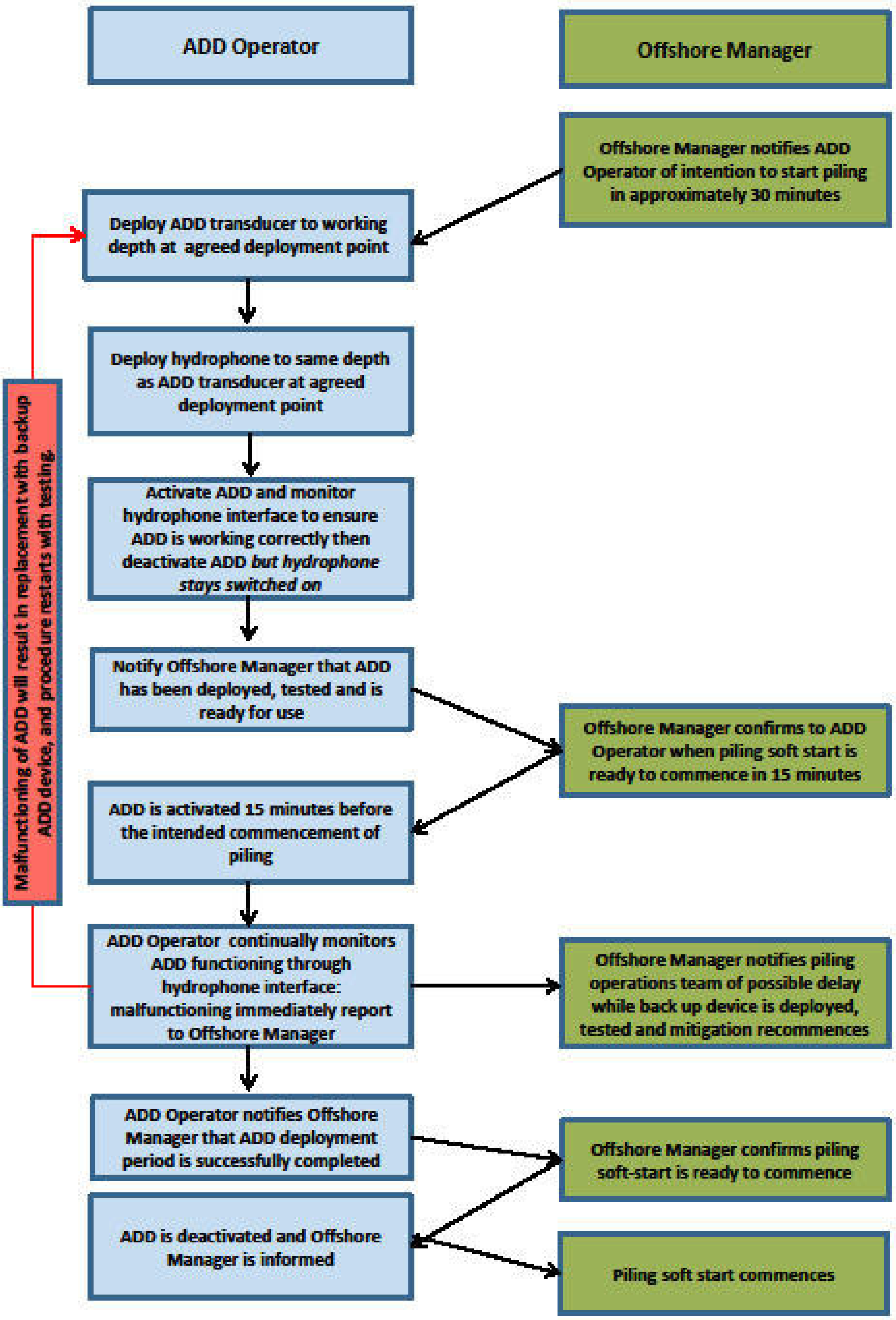
Figure C3 - Illustration of the computer interface for PAMGuard; screenshot shows a spectrogram of an ADD device (in this case an Airmar).



5. Task Plan

C1.14 The task plan presented in Figure C4 sets out, step by step, the tasks required for successfully completing the ADD mitigation, including the communication required at each step between the ADD Operator and the Offshore Manager.

Figure C4 - Task plan for undertaking mitigation using ADDs



C1.15 The process commences with notification to the ADD Operator that piling is due to commence in approximately 30 minutes. At this step, the ADD Operator will deploy the ADD and a hydrophone in order to test whether the ADD is functioning correctly. If there are any technical issues with the ADD, the device can be replaced with a spare, which similarly would be tested before progressing to the next step. Functioning of the ADD device will be monitored in real-time using PAMGuard software via a computer interface.

C1.16 Soft start piling will not commence until the ADD has been proven to function according to specifications and subsequently deployed for a period of 15 minutes as specified in the Piling Mitigation Protocol (Appendix D); notification of successful ADD deployment and functioning according to specifications for the required length of time will be made to the SHL Offshore Manager by the ADD operator to allow soft start piling to commence. Provision has also been made in the task plan for re-starting the sequence should the ADD device fail during the 15 minute deployment period.

C1.17 Soft start piling will not commence until the SHL Offshore Manager (role as described in Section 3 of the PS) has confirmation from the ADD Operator (role as described in Section 3 of the PS) that the ADD has been successfully deployed and is functioning according to specifications for the required length of time.

C1.18 Spare ADDs will be carried on board the HLV and deployed in the event of loss, damage or failure of primary equipment. Spare batteries will be available and kept charged by the ADD Operator in order to ensure the system is always available when required.

Additional Information

C1.19 After initial deployment of the hydrophone to test whether the ADD is functioning correctly, the hydrophone remains deployed until after cessation of the piling soft start. This will not only provide an auditable record of the testing and functioning of the ADD, it will also provide data on any cetaceans within the range of the hydrophone.

C1.20 Prior to and during the ADD deployment, the ADD Operator will record any marine mammals observations. Information from these observations will be recorded on a modified JNCC marine mammal recording form. Information that may be recorded includes, for example: species identification, number of adults or juveniles, behaviour, time and position (bearing and range) of the encounter, and direction of travel.

Planned and Unplanned Breaks

C1.21 Following a break in piling that is < 10 minutes the ADD will not be deployed prior to recommencing piling.

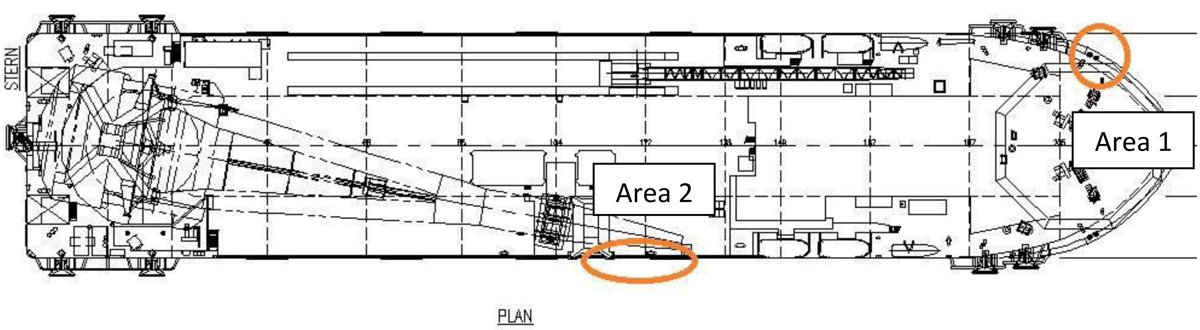
C1.22 Following a break in piling of <2.5 hours (see the Piling Mitigation Protocol), testing of the ADD will be completed simultaneously with the ADD deployment. Should the ADD not function properly the ADD operator will notify the SHL Offshore Manager to ensure that pile-driving does not commence until the ADD have been deployed and has been functioning according to its specifications for the required 10 minutes prior to recommencing piling.

6. Storage and Location of Deployment

C1.23 On board the Stanislav Yudin, the deck store on the portside fore or the deck office on the starboard side have been identified as a possible locations for storing and operating the control panel with the computer interface for the hydrophone also situated at one of these locations (Figure C5). This will provide an enclosed space to ensure that, in conditions with a higher sea state, there is less risk of damage by seawater. The ADD transducer can be deployed either on the port side near to the deck store (Area 1 on Figure C5 below) or on the starboard side by the deck office (Area 2 on Figure C5 below). An extension cable may or may not be required from the deck store where the control unit is stored to the transducer in order to ensure that the cable is sufficiently long for effective deployment and operation of the ADD device (see Section 1).

C1.24 The locations described above are indicative and it will be the responsibility of the ECoW to request the vessel details from SHL to provide these to the ADD Operator as soon as these are available. This will enable the ADD Operator to identify a suitable location for equipment storage and for deployment of the ADD and hydrophone as part of the initial risk assessment in collaboration with the SHL representative (Section 2).

Figure C5. Deck plan indicating possible locations for storing and operating the ADD device and computer interface for the hydrophone. Circles show the locations of the deck store (portside fore) (Area 1) and the deck office (starboard side) (Area 2) on board the *Stanislav Yudin*.



7. Reporting Methods

C1.25 The ADD Operators will report on piling operations and mitigation deployment during piling operations. Reports will include, but not be limited to the following:

- Locations of piling activity;
- Weather conditions during ADD deployment, including visibility.

- Start and end times of soft start piling and impact piling;
- Details of soft-start procedures and hammer energy employed at each piling location, including the duration of full-power piling;
- Confirmation that the ADD has been tested and is functioning as per specifications (see Appendix C), with auditable audio files to confirm effective functioning (to be submitted as hydrophone files);
- Time and duration of ADD deployment prior to piling events; and
- Observations of marine mammals during the testing and deployment of the ADD.

C1.26 The details of reporting provided by the ADD Operator tothe ECoW is detailed in Section 13 of the PS as it relates to reporting on the full mitigation scope (ADD and soft start piling).

8. Appendix C References

Brandt, M.J., Höschle, C., Diederichs, A., Betke, K., Matuschek, R., Witte, S., Nehls, G., (2013a). Far reaching effects of a seal scarer on harbour porpoises, *Phocoena phocoena*. Aquatic Conservation: Marine and Freshwater Ecosystems, 23 (2): 222-232.

Brandt, M.J., Höschle, C., Diederichs, A., Betke, K., Matuschek, R., Nehls, G. (2013b). Seal scarers as a tool to deter harbour porpoises from offshore construction sites. Marine Ecology Progress Series, 475: 291-302.

Gordon, J., Blight, C., Bryant, E., and Thompson, D., (2015) Tests of acoustic signals for aversive sound mitigation with common seals. Sea Mammal Research Unit Report to Scottish Government. June 2015. http://www.smru.st-andrews.ac.uk/pageset.aspx?psr=152.

Harris, R.N., Harris, C.M., Duck, C.D., and Boyd, I.L. (2014) The effectiveness of a seal scarer at a wild salmon net fishery. ICES Journal of marine Science, doi.10.1093/icesjms/fst216.

Sea Mammal Research Unit (SMRU) (2014). Marine Mammal Scientific Support Research Programme MMSS/001/11. Annual Progress Report. Sea Mammal Research Unit Report to Scottish Government. August 2014. V4.

Appendix D – Piling Mitigation Protocol

Protocol for mitigating the risk of instantaneous death or injury to marine mammals during piling at the BOWL and MORL Wind Farms

Paul Thompson [1] & Tessa McGarry [2]

2nd October 2015

1. University of Aberdeen, Institute of Biological & Environmental Sciences, Lighthouse Field Station, Cromarty IV11 8YL
2. RPS Energy, Riverside Court, Beaufort Park, Chepstow, Monmouthshire, NP16 5UH.

Contents

Background: To date the consents issued to offshore wind farms have focused on the current JNCC guidelines to minimise the instantaneous near-field impacts of piling on marine mammals (JNCC, 2010). Nevertheless these guidelines remain untested and a number of studies have criticised the reliance on these guidelines with calls for more effective mitigation (see Annex 3). Recent studies provide evidence that acoustic deterrent devices (ADDs) can result in aversive responses by both seals and cetaceans over ranges which are at least in the order of magnitude greater than predicted zones for instantaneous death and injury (see Annex 2). This indicates that they could be integrated into piling procedures along with soft start to provide more effective mitigation and improve the protection of marine mammals. This document (including Annexes 1-3) provides the proposals for mitigating the risk of instantaneous death or injury to marine mammals during piling at the BOWL and MORL wind farms.

Aim: This document outlines a procedure for mitigating the risk of instantaneous death or injury to marine mammals during piling at the BOWL and MORL wind farms, with the aim of developing the *Best Available Technique* [1] for balancing the highest level of environmental protection against commercial affordability and practicality.

Specific Objectives: To develop mitigation measures that can be integrated into a predictable and efficient engineering process that:

- minimises the risk of instantaneous death or injury (physical or auditory) for marine mammals during piling operations as a result of single noise pulses at close range;
- allows piling to be initiated in darkness, in poor visibility or after breaks in engineering works;
- can be used safely in an offshore environment in all seasons; and
- minimises the duration of the overall construction period.

Approach:

1. ***Optimise hammer energies to balance environmental risk and engineering requirements.*** Use available geotechnical data to predict the hammer energies required through the piling sequence to minimise the risk of pile refusal. Optimise piling sequence at each site to avoid unnecessary activity at full hammer energy (to minimise impact zones for instantaneous death and injury) and optimise hammer energies throughout the piling process (to minimise cumulative noise exposure).

[1] As defined in 2010 JNCC piling mitigation guidance.

2. ***Identify impact zones***. Estimate the size of impact zones for instantaneous death and injury based upon available geotechnical data, final pile sizes and predicted hammer energies at the start of each piling sequence (see Annex 1).

3. ***Develop site specific protocol for initiating the sequence of piling at each turbine location.*** This should involve the key elements outlined in Figure 1 (see page 5). The piling protocol presents the different steps (a to d) throughout the piling sequence with a justification of how the detail has been determined in each step. In addition, the piling protocol presents an illustration of how far an animal may be deterred (indicative cumulative distance) at each step in order to demonstrate that the protocol is sufficiently conservative to allow marine mammals to avoid the injury zone during piling.

    a. Deploy acoustic deterrent device (ADD) at the piling site for a period of 15 minutes (as agreed with the MFRAG-MM Subgroup at the meeting of the 19/06/2015), to allow marine mammals to be displaced out of the impact zones. Duration of ADD use to be based upon estimates of the size of the impact zone and likely swimming speeds. Herschel et al. (2013) recommend that the duration of mitigation should be tailored to allow all animals to swim twice the distance of the injury zone. Selection of ADD to be based upon available evidence on effective displacement of key receptors for each site (see Annex 2).

    b. Soft start commences with positioning the piling hammer and making 5-6 single blows at a low rate (approximately 1 blow per 10 seconds) using as low an energy as practically possible to check hammer operation and embed the pile into the ground. Although the energy level cannot be specified accurately (as this depends on equipment capabilities) the energy will not exceed 300 kJ (threshold set on the basis of 12%[2] of the maximum hammer size[3] of 2,500 kJ that may be employed during construction).

    c. Soft start continues with an increased blow rate of approximately 1 blow per 2 seconds. The minimum duration of soft start will be 20 minutes, consistent with JNCC guidelines. During this time soft start energy will be as low as possible for as long as possible (following recommendations by Herschel et al.

[2] For each halving of hammer energy there is a 3 dB reduction in sound and the ORJIP report on acoustic deterrent devices (Herschel et al. 2014) suggests that a tenfold reduction in hammer energy may be appropriate for initiating soft start as this represents a potential 10 dB reduction in sound. Whilst it may be possible to achieve this in practice, the thresholds here must be set according to the hammer manufacturers' specifications, which for a 2,500 kJ hammer is given as 12% or 300 kJ. This also represents a considerable reduction in sound of >9dB.

[3] Maximum hammer size is to be distinguished from maximum consented hammer energy.

(2013)), starting at an energy no higher than 300 KJ and not exceeding 500 KJ in the latter part of the soft start.

d. Continue to ramp up hammer energy gradually to the levels required to maintain pile movement at approximately 2.5 cm/blow up to the energy required to drive the pile up to target depth.

4. ***Develop site specific protocol to be used in planned or unplanned breaks in the sequence of piling at each turbine location.*** This should involve the key elements outlined in Figure 2 (see page 6).

   a. In the event of breaks in piling of < 10 minutes no additional mitigation would be required (i.e. the piling may continue from the hammer energy and frequency last used). For breaks in piling > 10 minutes[4] there are two possible outcomes as described in 4b. and 4c. below.

   b. Where duration of break is either unknown, or known to be less than 2.5 hours[5]

      i. deploy ADD for the same pre-determined period (as specified in 3a and as agreed with the MFRAG-MM Subgroup at the meeting of the 19/06/2015) immediately prior to resuming piling,

      ii. initiate piling with approximately 5 - 6 single blows at low energy; and

      iii. continue to ramp up hammer energy to the levels required to maintain pile movement at approximately 2.5 cm/blow.

   c. If the break is greater than 2.5 hours, or if the break occurs during the soft start procedure described under 3 (b. and c.)), re-start procedure as outlined in 3.

5. **Monitoring and Audit.** Establish an agreed monitoring system and an audit trail to demonstrate that:

   a. The ADD is operating according to specifications during all operations.

   b. Hammer energies remain within agreed limits within soft start periods.

   The detailed monitoring and reporting procedures can be integrated within each of the projects' Environmental Management Plans (EMPs) and Project Environmental Monitoring Programmes (PEMPs).

[4] JNCC guidelines state that if there is a pause of greater than 10 minutes, then the pre-piling search and soft-start procedure should be repeated (Section 2.5 in JNCC, 2010).

[5] Based on the deterrence time (total duration that animals are deterred from a disturbed area) of harbour porpoise estimated for the DEPONS model (van Beest et al. 2015) using the life-history parameters and fine-scale movement behaviour as described in model developed by Nabe-Neilson et al., (2014).

6. **Risk assessment.** Recognising that this protocol represents a change in procedures used for piling mitigation, and the efficacy of this protocol cannot be robustly demonstrated within appropriate timescales, undertake a risk assessment to assess the impact on protected marine mammal populations should key receptors not respond to the chosen ADD as expected. This risk-based approach should be used to place any risk from ineffective mitigation in the context of related impacts from piling noise (i.e. cumulative noise exposure and behavioural disturbance) that have previously been considered in the Environmental Statements (ES) and Habitats Regulations Assessment (HRA). A risk assessment has been undertaken for the BOWL and MORL sites, demonstrating that adoption of these new mitigation procedures should present negligible additional risk to the key receptor population in the Moray Firth (see Annex 3).

Figure 1. Schematic providing an example of a piling mitigation procedure based on the general guidelines outlined in section 3.

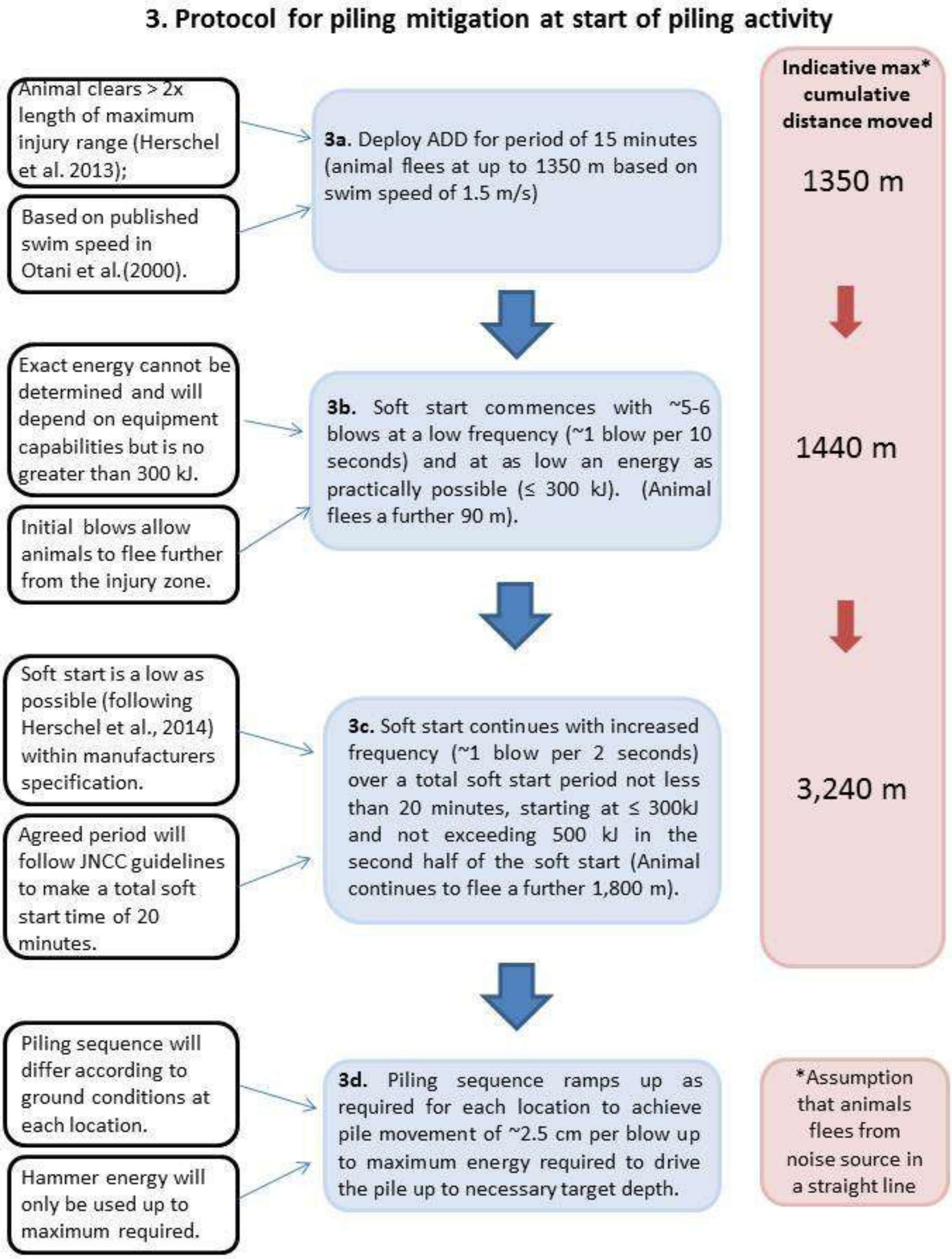
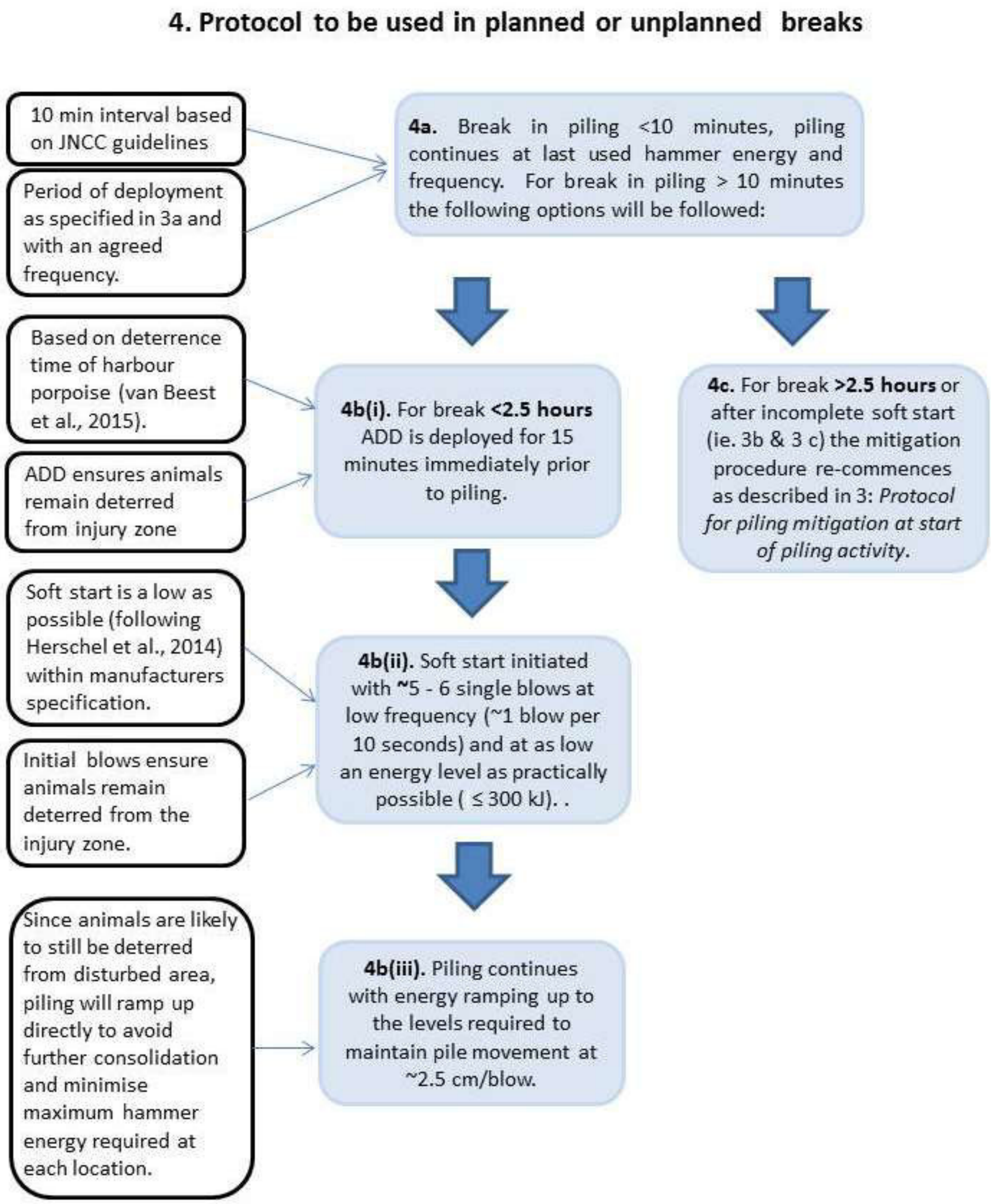


Figure 2. Mitigation protocol to be used in a planned or unplanned break from piling with distinction made between longer breaks and short breaks up to 2.5 hours.



References:

Herschel, A., Stephenson, S., Sparling, C., Sams, C., Monnington, J. (2013). Use of Deterrent Devices and Improvements to Standard Mitigation during Piling. ORJIP Project 4, Phase 1. Xodus Group Ltd. Document L-300100-S00-REPT-002.

Nabe-Nielsen, J., Sibly, R. M., Tougaard, J., Teilmann, J. and Sveegaard, S. (2014) Effects of noise and by-catch on a Danish harbour porpoise population. Ecological Modelling 272: 242-251.

Otani,S., Naito,Y., Kato,A., Kawamura,A. (2000) Diving behaviour and swimming speed of a free-ranging harbor porpoise, *Phocoena Phocoena*. Marine Mammal Science 16: 811-814.

van Beest, F.M, Nabe-Nielsen, J., Carstensen, J., Teilmann, J. & Tougaard, J. 2015: Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS): Status report on model development. Aarhus University, DCE – Danish Centre for Environment and Energy, 43 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 140 (http://dce2.au.dk/pub/SR140.pdf).

Annex 1.

Identification of impact zones

The following criteria should be used to identify the noise levels likely to cause instantaneous death or injury around piling operations using different pile sizes and hammer energies (eg. MORL ES Section 4.2.2 Technical Appendix 3.6A).

Death – may occur where peak-peak levels exceed 240 dB re 1 µPa

Injury (physical or auditory) - may occur where peak-peak levels exceed 220 dB re 1 µPa

In addition instantaneous auditory injury thresholds have been defined based upon Southall et al's (2007) single pulse PTS thresholds, expressed either in terms of a peak pressure level or an M weighted sound exposure level (SEL). More recent studies of harbour porpoise TTS thresholds (Lucke et al. 2009) have led to proposals for a revised single pulse PTS threshold for these high frequency cetaceans (ORJIP Project 4 Phase 1 Report p 139).

Species	Single pulse PTS Thresholds	
	SEL	Unweighted peak pressure
High-Frequency Cetacean (Southall et al. 2007)	M-weighted 198 dB re 1 µPa^2s	200 dB re 1 µPa
Mid-Frequency Cetacean (Southall et al. 2007)	M-weighted 198 dB re 1 µPa^2s	230 dB re 1 µPa
Low-Frequency Cetacean (Southall et al. 2007)	M-weighted 198 dB re 1 µPa^2s	230 dB re 1 µPa
High-Frequency Cetacean (based on Lucke et al. 2009)	Unweighted 179 dB re 1 µPa^2s	200 dB re 1 µPa
Pinniped (Southall et al. 2007)	M-weighted 186 dB re 1 µPa^2s	218 dB re 1 µPa

In the BOWL and MORL ES's the risk of instantaneous death was estimated to occur only at extremely short distances and the risk of instantaneous injury at less than 38 m.

For this assessment, CEFAS conducted additional modelling to provide a conservative estimate of impact ranges for a 300 kJ initial hammer energy. This assumed an energy conversion efficiency of 1%, which is at the upper limit of field observations (Ainslie et al. 2012; Dahl et al. (2015). This 300 kJ strike equates to 205.6 dB of acoustic energy as a single pulse SEL (de Jong & Ainslie 2008). A propagation loss of 15*log(R) was assumed due to cyclindrical spreading in these relatively shallow waters, where R is range from the source, and an unweighted threshold of 179 dB re 1 µPa^{2}s (Lucke et al. 2009) was used to safeguard the most sensitive of marine mammals, including harbour porpoise. This suggests that the maximum range at which instantaneous injury might occur is <60m.

Estimating the time required for marine mammals to be displaced from injury zones

Following recommendations in the ORJIP Project 4 Phase 1 Report (p 142), ADD should be deployed for long enough for animals to swim twice the radius of the appropriate injury zone. The Piling Mitigation Protocol provides for marine mammals to clear an area an order of magnitude greater than this.

Following the approach taken in the ORJIP Project 4 Phase 1 Report (p141) these calculations should assume a minimum swimming speed of 1.5 m/s (Otani et al. 2000).

References:

Ainslie, M. A., de Jong, C. A., Robinson, S. P., & Lepper, P. A. (2012). What is the source level of pile-driving noise in water? In: The Effects of Noise on Aquatic Life (pp. 445-448). Springer New York.

Dahl, P.H., de Jong, C.A.F. & Popper, A. (2015). The underwater sound field from impact pile driving and its potential effects on marine life. Acoustics Today, 11, 18-25.

De Jong, C. A. F., & Ainslie, M. A. (2008). Underwater radiated noise due to the piling for the Q7 Offshore Wind Park. J Acoust Soc Am 123: 2987.

Herschel, A., Stephenson, S., Sparling, C., Sams, C., Monnington, J. (2013). Use of Deterrent Devices and Improvements to Standard Mitigation during Piling. ORJIP Project 4, Phase 1. Xodus Group Ltd. Document L-300100-S00-REPT-002.

Otani,S., Naito,Y., Kato,A., Kawamura,A. (2000) Diving behaviour and swimming speed of a free-ranging harbor porpoise, *Phocoena Phocoena*. Marine Mammal Science 16: 811-814.

Lucke K, Siebert U, Lepper PA, Blanchet MA (2009) Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. J Acoust Soc Am 125: 4060–4070

Southall B.L., Bowles A.E., Ellison W.T., Finneran J.J., Gentry R.L., Jr C.R.G., Kastak D., Ketten D.R., Miller J.H., Nachtigall P.E., et al. 2007 Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals 33: 411-521.

Annex 2. Deployment of acoustic deterrent devices.

Choice of ADD. Selection of ADD devices should be based upon the available evidence at the time of procurement given the suite of key receptors at a particular site. Based upon the current literature and the ORJIP review of available devices, it is anticipated that this could be a Lofitech Seal Scarer. A review of available literature on the performance of this device can be found on p 149 of the ORJIP Project 4 Phase 1 Report (Herschel et al. 2013).

In summary, marine mammals with both high frequency (harbour porpoise) and low frequency (harbour seal) have been shown to respond to the Lofitech Seal Scarer. Of particular relevance to the Moray Firth developments are the studies of harbour porpoises in the Danish Baltic Sea, where the use of the Lofitech Seal Scarer decreased sighting rates within 1 km to only 1% of baseline (see Figure 4 and Brandt et al. 2013a). Similarly, in the German North Sea waters, deployment of the Lofitech Seal Scarer resulted in significant decrease in harbour porpoise click activity (recorded using C-PODs) at 750 m and at 3,000 m from the source (Brandt et al. 2013b). Notably, at 750 m recovery was found to be gradual with a significant deterrence effect lasting up to 4 to 6 hours after the Lofitech Seal Scarer was turned off, suggesting that effects are likely to last no longer than 6 hours at this distance (Brandt et al. 2013b).

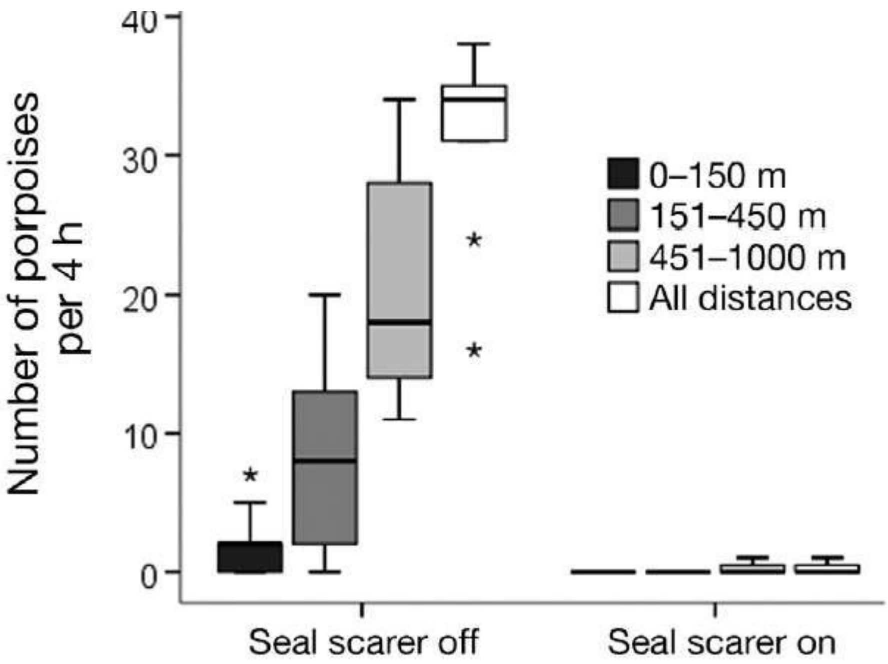


Fig 4 from Brandt et al. (2013) showing variation in sightings rate during observation periods when the Lofitech Seal Scarer was turned on compared to when the Lofitech Seal Scarer was turned off.

Further studies of responses of Moray Firth harbour seals to this device have been conducted both in river systems (Graham et al. 2009) and open water (SMRU Unpublished data). Graham et al's (2009) study showed that use of the device reduced upstream movements of seals by 50%, even though seals are likely to have been strongly motivated to travel upstream to forage on salmonids. Studies conducted for Marine Scotland by SMRU indicate that in open water a behavioural response was observed for all 38 controlled exposure experiments for which a tagged harbour seal was within 1 km of the source, and responses were recorded to a maximum range of > 3km.

Methods for deployment of ADD. A single device should be deployed as close as possible to the piling site, ideally so that the deployment is fully integrated with the engineering process (eg. through remote operation of a device deployed from the piling vessel).

Timing of deployment of ADD. Decisions over the duration of ADD use should seek to balance the key objective of dispersing animals from the injury zone against any risks of habituation to the ADD source, cumulative noise exposure to the ADD source or broader scale disturbance.

Following ORJIP recommendations (Herschel et al. 2013), the duration of deployment at start of piling sequence should be sufficient to allow individuals to travel 2x the distance of the injury zone at a cruising speed of 1.5m/sec.

- Eg. for a 60m injury zone, ADD deployment of just 1.5 minutes would permit animals to swim beyond the required 120 m.

To minimise excessive disturbance and habituation, whilst also ensuring sufficient time for animals to clear the injury zone there should be an agreed duration for each ADD deployment. Following submission of a draft of this Piling Mitigation Protocol, this was discussed with the SNCBs, and the duration for ADD deployment was agreed as 15 minutes.

References:

Brandt, M. J., C. Höschle, A. Diederichs, K. Betke, R. Matuschek, and G. Nehls. 2013a. Seal scarers as a tool to deter harbour porpoises from offshore construction sites. Marine Ecology Progress series 475: 291-302.

Brandt MJ, Höschle C, Diederichs A, Betke K, Nehls G (2013b) Far reaching effects of a seal scarer on harbour porpoises, *Phocoena phocoena*. Aquat Conserv: Mar Freshw Ecosyst 23: 222-232.

Graham, I. M., R. N. Harris, B. Denny, D. Fowden, and D. Pullan. 2009. Testing the effectiveness of an acoustic deterrent device for excluding seals from Atlantic salmon rivers in Scotland. ICES Journal of Marine Science 66: 860-864.

Herschel, A., Stephenson, S., Sparling, C., Sams, C., Monnington, J. (2013). Use of Deterrent Devices and Improvements to Standard Mitigation during Piling. ORJIP Project 4, Phase 1. Xodus Group Ltd. Document L-300100-S00-REPT-002.

Annex 3. Framework for a risk-based assessment to underpin the adoption of alternative mitigation measures during piling at the BOWL and MORL Offshore Wind Farms

Paul Thompson, 28th September 2015

Overview

There is widespread interest in the use of Acoustic Deterrent Devices (ADDs) as an alternative to Marine Mammal Observers (MMO) and Passive Acoustic Monitoring (PAM) when mitigating the risk of death or injury to marine mammals during offshore piling. However, decisions on the most appropriate mitigation during construction of the Moray Firth developments remain constrained by stakeholder concerns over the relative efficacy of ADDs and the current JNCC guidelines.

To inform decisions about the potential risk of using these alternative piling mitigation measures, an assessment of the potential risk to different marine mammal species in the absence of ***any*** piling mitigation has been developed. To place this risk in the broader population context considered within the original Environmental Statements (ES) and Habitats Regulations Assessments (HRA), the Moray Firth Harbour Seal Assessment Framework has been used to re-assess the long-term population consequences for this key receptor species. In doing so, the effects of post-consent changes in the project design and construction programme have been explored, comparing the original worst case ES scenarios with new worst case scenarios for BOWL and MORL together based on the current design layout. In addition, the potential risk of injury from scenarios in which piling occurred only within the BOWL or the MORL wind farms were developed to support individual EPS Licence applications.

Current JNCC guidelines are assumed to reduce the potential risk of injury or death to negligible levels. The analyses presented here suggest that, in the absence of any piling mitigation, the risk of marine mammals being within sufficiently close range to result in instantaneous death or injury is also negligible even when considering effects from both BOWL and MORL developments together. Thus, the adoption of alternative mitigation measures using ADD should either equal or exceed the level of protection assumed to result from the current JNCC guidelines.

Background

The key impacts of wind farms on marine mammal populations that are likely to result from pile-driving during construction [1] are:

(1) Instantaneous death or injury (physical or auditory) from single noise pulses at close range
(2) Auditory damage from accumulated noise doses
(3) Behavioural disturbance

In the Environmental Statements (ES) for the Moray Firth developments, the distances at which each of these effects might occur were based upon best available scientific evidence from noise propagation modelling and published marine mammal noise exposure criteria [2]. These data indicated that instantaneous death or traumatic injury should occur only at distances of < 40m (see Table 1). In contrast, behavioural disturbance and the impacts of cumulative noise exposure were predicted to occur at much greater distances. For example, piling noise exposure amongst harbour seals could exceed Southall et al.'s (2007) Permanent Threshold Shift (PTS) threshold for auditory damage [2] at distances of > 10-15km.

In 2010, building on related guidelines for seismic surveys [3], guidance was produced by JNCC to mitigate injuries that might result from pile-driving activity. These require the use of Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM) to minimise the likelihood that a piling sequence is initiated when marine mammals are within a 500m mitigation zone. When assessing the population consequences of piling activity within the Moray Firth developments, it was assumed that close range impacts resulting in instantaneous death or injury would be avoided through adoption of the 2010 JNCC guidelines [4]. Given that cumulative noise exposure may lead to PTS over ranges in excess of 10km, JNCC guidelines clearly provide negligible protection against the effects of any far field auditory damage resulting from cumulative noise exposure, or indeed for behavioural disturbance. The population effects of these other unmitigated residual impacts were assessed in the ES as resulting in no significant long term effects, and the Habitats Regulations Assessment (HRA) concluded that they did not affect the long term conservation status. Efforts have been made to further reduce any of these longer range impacts through post-consent changes in the design layout. Furthermore, post-consent geotechnical investigations are currently underpinning the development of strategies that aim to minimise the cumulative energy required to drive each pile into the seabed. The requirement for mitigation at the start of each piling process is therefore to reduce the risk of instantaneous death or traumatic injury to negligible levels at the start of each of these piling sequences.

The need for alternative mitigation measures

Although a pragmatic first step towards minimising the impacts of noise on marine mammals, the 2010 JNCC guidelines remain untested. Reliance on the guidelines has subsequently received criticism in the scientific literature, with calls for more effective mitigation [5]. In particular, it is recognised that the probability of visually detecting marine mammals at sea is extremely low [6]. Furthermore, the probability of detection by Passive Acoustic Monitoring (PAM) systems is known to be zero for some key receptors such as harbour seals, and is uncertain for all other species [7].

Recognising these issues, there is widespread agreement over the need for more effective measures to mitigate the risk of instantaneous death or injury at close range. Recent studies provide evidence that at least one commercially available Acoustic Deterrent Device (ADD) can result in behavioural responses by both seals and cetaceans over ranges which are at least an order of magnitude greater than predicted zones for instantaneous death and injury [8, 9]. This suggests that ADDs may be a more effective tool than MMOs and PAM where mitigation aims to maximise the likelihood that animals are outside predicted impact zones at the start of piling.

Consequently, ADDs and soft start piling could be integrated into new procedures for offshore piling that should provide more effective mitigation and improve the protection of marine mammals. This approach would also provide greater certainty in engineering timelines, avoiding delays due to the onset of night time, poor weather and MMO detections. This would have three additional benefits:

1) Greater economic certainty for overall construction plans. This would increase the likelihood of individual developments going forward and contributing to the UK's efforts to meet current climate change targets.
2) Greater certainty in timelines for individual piling events. This would improve the optimisation of piling events within predicted weather windows and reduce HSE risks.
3) Overall reduction in the construction period. This would reduce broader scale disturbance from vessel activity. A shorter construction period would likely also have wider environmental benefits by reducing impacts on other receptors and producing less carbon.

Whilst ADDs have been used in conjunction with MMOs under JNCC guidelines in some regions, discussion within the Offshore Renewables Joint Industry Programme (ORJIP) has highlighted that there are strong stakeholder concerns over the adoption of ADDs as an alternative to the temporal restrictions which would result from the use of MMOs and PAM. Most critically, Statutory Nature Conservation Bodies (SNCBs) are currently requesting scientific evidence that ADDs are more effective than current JNCC guidelines before agreeing to their use as an alternative mitigation measure. This raises two key challenges for regulators and the industry:

1) Given there has been no assessment of the efficacy of current JNCC guidelines, it is unclear how proposed studies might demonstrate that ADDs are more effective than this unknown baseline.
2) Given the global experience of previous behavioural response studies, it is unclear whether a viable experiment can be designed to provide the expected level of confidence in the effectiveness of ADDs as an alternative mitigation measure.

BOWL and MORL are currently developing piling strategies that must be economically viable and accepted by key stakeholders. Critically, project milestones dictated by DECC mean that this process must be completed in Q4 2015. In contrast, even if suitable research projects could be designed and commissioned through ORJIP, results would not be available for at least 2 years, well beyond the timescales required for approval of the projects' piling strategies. Decisions on the potential use of ADDs within the BOWL and MORL piling strategies must therefore be made on the existing evidence base. Currently, however, these decisions are constrained because of SNCB and Regulator concern that the adoption of alternative mitigation measures using ADD may result in unacceptable risks.

Aims

This document develops a framework that aims to allow regulators to assess whether the risk of using ADDs as an alternative form of piling mitigation is acceptable.

Given the challenges outlined above, the proposed approach involves assessing the consequences of a complete failure in the efficacy of ***any*** of the potential mitigation measures.

If it can be demonstrated that there is negligible additional risk to these populations in the absence of any effective mitigation for near-field impacts, then the use of (potentially more effective) alternative mitigation measures using ADDs should either equal or exceed the level of protection assumed to result from the current JNCC guidelines.

Framework overview

The general approach used in this risk assessment was to use site specific density data to estimate the likelihood that randomly distributed individuals may be close enough to a pile to be killed or injured at the start of a single piling sequence. The BOWL Wind Farm layout includes 84 turbines, two offshore transformer modules (OTMs), and two spare locations, each requiring four piles with a maximum diameter of 2.2m. The first phase of the MORL development (Project 1) will not exceed 100 turbines, with a maximum of 4 piles per turbine, and up to 16 piles for each of the up to two Offshore Substation Platforms (OSPs). This information was used to estimate the likelihood of an individual being killed or injured at the start of the resulting maximum number of piling events during the construction period for each scenario. This maximum number was 784 piling events for both projects together, 352 for BOWL only[6] and 432 for MORL Project 1 only scenarios. These calculations were made for all five marine mammal species considered in the ES (Harbour Seal, Grey Seal, Bottlenose Dolphin, Harbour Porpoise & Minke Whale). For harbour seals, the numbers of individuals that might be impacted in the absence of effective mitigation of these close-range impacts were also included in revised scenarios of the Seal Assessment Framework used in the BOWL and MORL ES's. This was then used to compare the long term population consequences of the worst case cumulative construction scenario, with and without mitigation.

Figure 1 provides an overview of the approach used, illustrating where information was drawn from the existing ES's and where new outputs have been generated. More detailed information on the methods used is presented below. As for the Seal Assessment Framework, the approach aimed to be conservative. For example, when generating random distributions of animals, it was assumed that the presence of vessels prior to piling did not disturb any individuals from the immediate vicinity of the piling vessel. Other key assumptions are listed in The Annex.

Potential impact zones were based on ES predictions of the distances at which different species may be killed or physically injured instantaneously from a single loud pulse. The approaches used in the

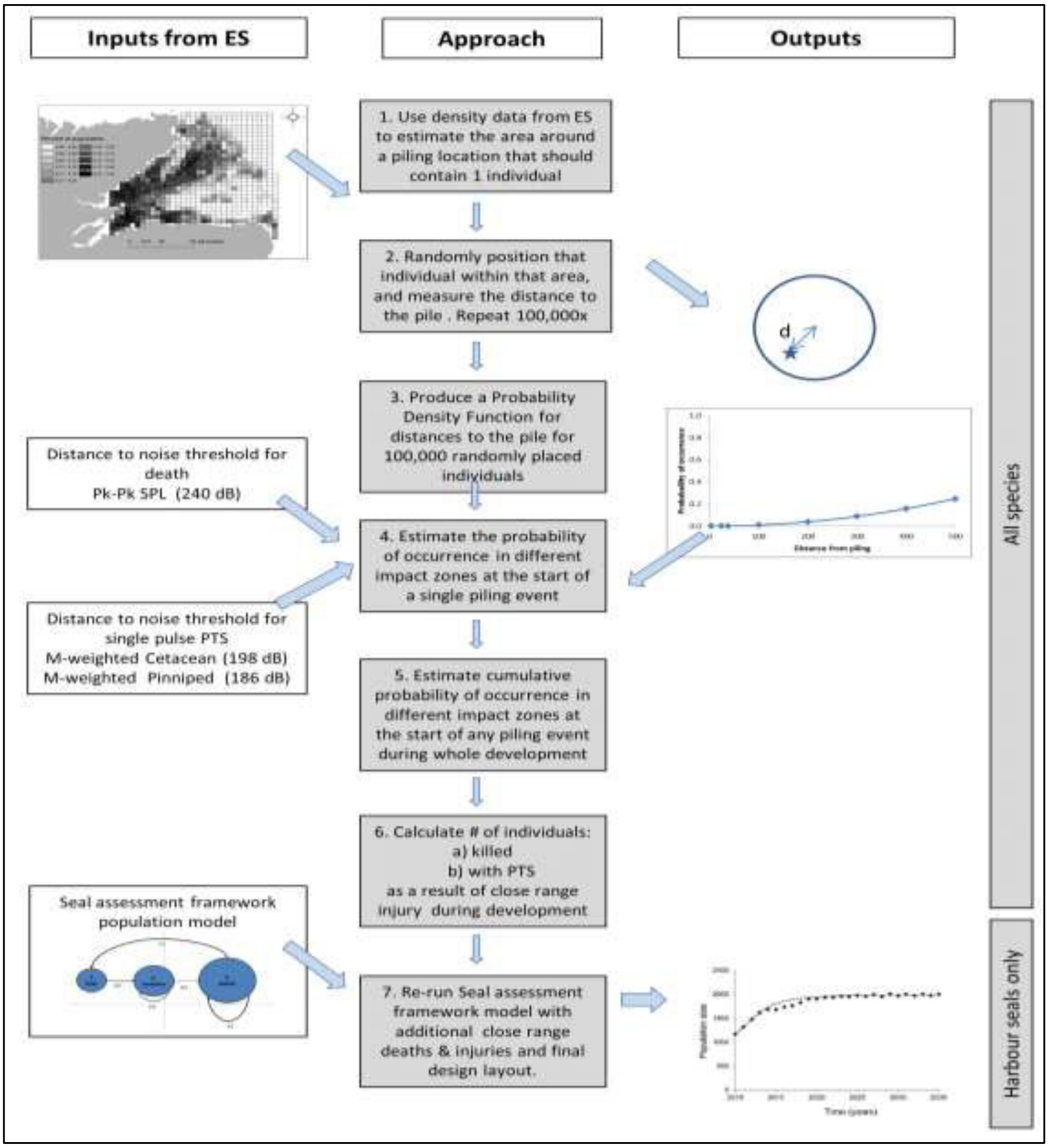
[6] This included 2 spare locations as a worst case scenario

BOWL and MORL ES's varied slightly (Table 1) but, in both cases, risk of death occurred only at extremely short range with risk of instantaneous injury always being <40m. To assess the potential risk of instantaneous injury from a 300 kJ soft start as proposed for the BOWL and MORL Project 1 developments, risk assessments were also used for a more conservative 60m impact zone (see Annex 1 of main document).

Table 1. Distance bands used to estimate close-range impacts of piling

Distance Band	Impact	Species	Criteria	Source
2m	Death	All Marine Mammals	Unweighted pk-pk SPL of 240 dB re. 1µPa (Lethality). Based on a 1200 kJ hammer and a 2.5m pile.	MORL ES Appendix 3.6a, S. 4.2.2.)
4m	Injury	Cetaceans	M weighted single pulse PTS criteria of 198 dB re. 1µPa^2-s. Based on a 360kJ hammer on soft start and a 1.8m pile.	Southall et al (2007) BOWL Supp. noise modelling (unpubl.)
24m	Injury	Pinnipeds	M weighted single pulse PTS criteria of 186 dB re. 1µPa^2-s. Based on a 360kJ hammer on soft start and a 1.8m pile.	Southall et al (2007) BOWL Supp. noise modelling (unpubl.)
38m	Injury	All Marine Mammals	Unweighted pk-pk SPL of 220 dB re. 1µPa (Injury). Based on a 1200 kJ hammer and a 2.5m pile.	MORL ES Appendix 3.6a, S. 4.2.2.)
60m	Injury	All Marine Mammals (based upon harbour porpoise being most sensitive)	Unweighted single pulse PTS criteria of 179 dB re. 1µPa^2-s. Based on a 300kJ hammer energy on soft start.	Annex 1 of main document
500m	N/A	All Marine Mammals	MMO Mitigation Zone	JNCC (2010)

Figure 1. Schematic showing the general approach used to compare the population consequences of variations in the efficacy of mitigation measures used to reduce the impacts of instantaneous death or injury around a piling site.



Methods

Estimating marine mammal occurrence within different impact zones at the start of piling sequences

Predicted distributions were based on the density estimates for each of the marine mammal species that were assessed in the BOWL and MORL ES's. Density estimates for impacts of BOWL and MORL together were based on mean values across all grid cells within the two development zones, whilst density estimates for BOWL and MORL alone were based on the mean values within each individual development site (Table 2). For each species, density data were used to estimate the area and radius of a circle around each piling site that should include one individual (Table 2).

Individuals were then randomly positioned within these circles and their distance from the pile was measured. This was repeated 100,000 times to estimate the probability of individuals being present within different zones at the start of any individual piling sequence.

If each piling event is assumed to be independent (see the Annex to this Risk-based Framework Assessment), the probability of an individual marine mammal occurring within each impact zone during the first piling strike of any of the 784 piles required for construction of the BOWL and MORL Project 1 wind farms can be calculated from the cumulative binomial probability. This approach can also be used to estimate the maximum number of occasions on which an individual is likely to be present in each zone over the sequence of 784 piling events (here estimated using a 95% probability level). These probabilities were also calculated separately for the individual projects, although to simplify the analysis, the focus was on estimating the probability of occurrence within the 60m injury zone only (as this is the most relevant to the Piling Mitigation Protocol), rather than repeating for all the distance bands.

Table 2. Estimates of density within the Moray Firth development areas, with estimated circle radii that would be expected to contain one individual. Separate estimates were produced for BOWL only, MORL only and impacts for BOWL and MORL Project 1 together based upon local densities within each site

	Mean density (individuals per km^2)	Radius of circle containing one individual (m)
BOWL + MORL		
Harbour Seal	0.31	1020.7
Grey Seal	0.15	1456.0
Harbour Porpoise	0.862	607.7
Bottlenose Dolphin	0.00016	44514.4
Minke Whale	0.022	3803.8
BOWL		
Harbour Seal	0.312	1010.2
Grey Seal	0.119	1638.1
Harbour Porpoise	0.926	586.3
Bottlenose Dolphin	0.00006	70711.8
Minke Whale	0.022	3803.8
MORL		
Harbour Seal	0.304	1023.8
Grey Seal	0.159	1413.1
Harbour Porpoise	0.843	614.5
Bottlenose Dolphin	0.00019	41021.3
Minke Whale	0.022	3803.8

Assessing the population consequences of not mitigating instantaneous death and injury

Assessments of population level impacts were only made for one of the Moray Firth's priority species; harbour seals. This was because the estimated density of bottlenose dolphins in the Outer Moray Firth is so low that the cumulative probability of this second priority species occurring even within a 500m mitigation zone around piling events was <0.1 (see results below).

Population trajectories were compared for different construction scenarios with effective mitigation and without any mitigation to prevent instantaneous death or injury. These comparisons were developed using baseline models from the Moray Firth Seal Assessment Framework. Worst case scenarios used in the BOWL and MORL ES's were first adapted to reflect subsequent changes in the scale of each development (see Table 3), and these were used as baseline construction scenarios assuming that effective mitigation was in place.

These baseline construction scenarios already incorporated impacts of wind farm construction through (1) reductions in survival as a result of PTS from cumulative noise exposure (where 25% of animals that suffer injury from PTS will subsequently die) and (2) declines in reproduction as a result of behavioural displacement (where 100% of animals that suffer behavioural displacement will have reproductive failure in that year) [4]. In addition, baseline construction scenarios include the annual shooting of individuals due to licenced killing by fisheries interests. Any additional impacts from unmitigated instantaneous deaths can therefore be incorporated by supplementing the annual removals from shooting. Any additional impacts from unmitigated instantaneous injury can be incorporated by supplementing the number of individuals with PTS. In addition, an extreme worst case scenario was developed for the unmitigated injuries that assumed 100% mortality as a result of those injuries. In each of these cases, the numbers of individuals were based on the cumulative probability of an individual occurring within the different impact zones (see Table 1) during the initiation of piling at any of the 784 piling events during the entire BOWL and MORL Project 1 construction periods.

Table 3. Comparison of key piling parameters used in the ES worst case scenarios and the current design basis layout for the BOWL and MORL developments.				
Parameter	BOWL		MORL[7]	
	ES Worst case	Design Basis Layout	ES Worst case	Project 1 Indicative Design
Number of turbines	277 x 3.6 MW	84 x 7 MW	339	< 100
Total piling phase for a single vessel	3 years	1.5 years	5 years	2 years

Overall, seven construction scenarios, with different combinations of mitigation and injury severities were compared as outlined in Table 4. These included one of the original ES worst case scenarios, and three variations for each of two different revised construction scenarios. The first revised construction scenario (Revised A) involved a four year construction period, and the second (Revised B) involved a three year construction period. The three variants of each related to whether or not there was mitigation and the mortality rate resulting from PTS (Table 4; Annex to this Risk-based Framework Assessment). To allow comparison with outputs from the ES, the first year of construction was set at 2014 in all cases. Similarly, to facilitate comparison of the effects of any mitigation, models were run using the best fitting curve for behavioural displacement and a carrying capacity of 2000. For further details see relevant ES sections [4]. The primary difference between these scenarios and those used in the ES relates to the numbers of turbines in the final layout, and the consequences that this has on the number of vessels used and the duration of construction. The main comparisons retain the original ES assumption that displacement leads to 100% failure in reproduction. However, the reduction in turbine numbers at both sites means that most piling is likely to occur in the summer months, and emerging data from DECC SEA funded studies in the Wash further indicate that displacement during piling is more limited in both space and time than predicted in the ES. In one additional scenario, we therefore explore the effects of reducing this conservatism in the impacts of displacement to a more probable worst case of a 50% failure in reproduction (see Annex to this Risk-based Framework Assessment).

[7] MORL has received three Section 36 consents for a maximum total capacity of 1,116 MW generated by not more than 186 turbines. MORL is planning to develop the area through a phased approach. The first phase of development (Project 1) is currently being developed pending announcements of a future Contract for Difference (CfD) allocation round. However, MORL anticipates that Project 1 will not exceed 100 turbines with the balance being developed in a subsequent phase(s).

Table 4. Summary of the different indicative construction scenarios modelled to explore the consequences of not mitigating instantaneous death and injury					
Model Scenario		Duration	Construction Scenario (see ES)	Mitigation	Mortality rate from instantaneous injury
1	ES Worst Case Cumulative A	5 yrs	2 piling vessels on BOWL for 2 yrs followed by: 2 piling vessels on MORL for 3 yrs	Yes	-
2	Revised A	4 yrs	1 piling vessel on BOWL for 2 yrs followed by: 1 piling vessel on MORL for 2 yrs	Yes	-
3		4 yrs		No	25%
4		4 yrs		No	100%
5	Revised B	3 yrs	1 piling vessel on BOWL for 1 yr followed by 1 piling vessel on BOWL + 1 piling vessel on MORL for 1 yr followed by 1 piling vessel on MORL for 1 yr	Yes	-
6		3 yrs		No	25%
7		3 yrs		No	100%

Results

Estimating marine mammal occurrence within different impact zones at the start of piling sequences for BOWL and MORL Project 1together.

The probability that individuals of any of the five species of marine mammals were within the instantaneous death or injury zones at the beginning of a single piling event was extremely low in all cases (Table 5a). Probabilities are provided for relevant injury zones (death, PTS from instantaneous M weighted single pulse criteria for seals and cetaceans and physical injury) as shown in Table 1. For instantaneous death (within 2m) this was always ≤ 0.0001, and for instantaneous physical injury (within 60m) this was always < 0.05, even using the most conservative case of a harbour porpoise and a 300KJ hammer. In contrast, the probability that individuals may be present within the 500m mitigation zone at the beginning of a single piling event was sometimes much higher, and only extremely low (<0.01), for bottlenose dolphins. In particular, the probability that an individual may be present within the 500m zone at any single point in time was 0.68, for harbour porpoise, and 0.24 for harbour seals (Table 5a).

The cumulative probability for each of the five species being within the instantaneous death zone during the first strike of any of the 784 piling events was also extremely low (<0.01) for all species (see Table 5b). However, cumulative probabilities suggest that, with the exception of bottlenose dolphin, one cannot have 95% confidence that individuals are likely to be absent from the instantaneous injury zones during all the first piling strikes. Conversely it is almost certain (≥99%

probability) that all species except bottlenose dolphin will be present within the 500m mitigation zone during at least one first piling strike of the 784 piling events.

The cumulative probabilities can also be used to place an upper 95% confidence limit on the number of occasions (from the total of 784 piling events) on which individuals might be present in different zones during the first piling strike as shown in Table 5c. Table 5b indicates that there is a cumulative probability of 0.97 that a harbour seal will be present in the 60m single pulse PTS zone at the start of at least one of the 784 piling events. While Table 5c indicates that there is a 95% probability that this will not occur on more than 7 different occasions.

The data in Table 5c can therefore be used to put an upper limit on the number of individuals that may be affected by these instantaneous injuries during the construction period. These values can subsequently be used to assess population consequences, and assess the relative importance of these impacts compared with previously assessed impacts from cumulative noise exposure or behavioural disturbance. Here, this is explored for harbour seals through the Moray Firth Seal Assessment Framework, but data for other species such as harbour porpoise could be compared, for example, with estimates of Potential Biological Removal (PBR) [10, 11].

Similarly, data in Table 5c can be used to provide an indication of the number of times that different species may be present within the 500m mitigation zone (as detailed within JNCC guidelines as discussed above) during the construction period. These data suggest that harbour seals may be present within the mitigation zone during up to 208 (26%) of the first piling strikes, whereas harbour porpoises may be present during up to552 (70%) of these events.

Table 5. Probabilities for each species occurrence in each distance ban. Estimates are based on the BOWL + MORL Project 1 scenario using average densities across the two sites (see Table 2)

a) Probability of an individual being present in each distance band during the first strike of a single pile

	2m	4m	24m	38m	60m	500m
Harbour Seal	0.00001		0.00056	0.00136	0.0045	0.24109
Grey Seal	<0.00001		0.00038	0.00076	0.00218	0.11772
Harbour Porpoise	<0.00001	0.00003		0.00389	0.01293	0.67604
Bottlenose Dolphin	<0.00001	<0.00001		<0.00001	<0.00001	0.0001
Minke Whale	<0.00001	<0.00001		0.00016	0.0004	0.01697

b) Cumulative probability of an individual being present in each zone during at least one of the 784 first piling strikes

	2m	4m	24m	38m	60m	500m
Harbour Seal	<0.01		0.36	0.66	0.97	<1
Grey Seal	<0.01		0.26	0.45	0.82	<1
Harbour Porpoise	<0.01	<0.03		0.95	<1	<1
Bottlenose Dolphin	<0.01	<0.01		<0.01	<0.01	<0.1
Minke Whale	<0.01	<0.01		0.12	0.27	< 1

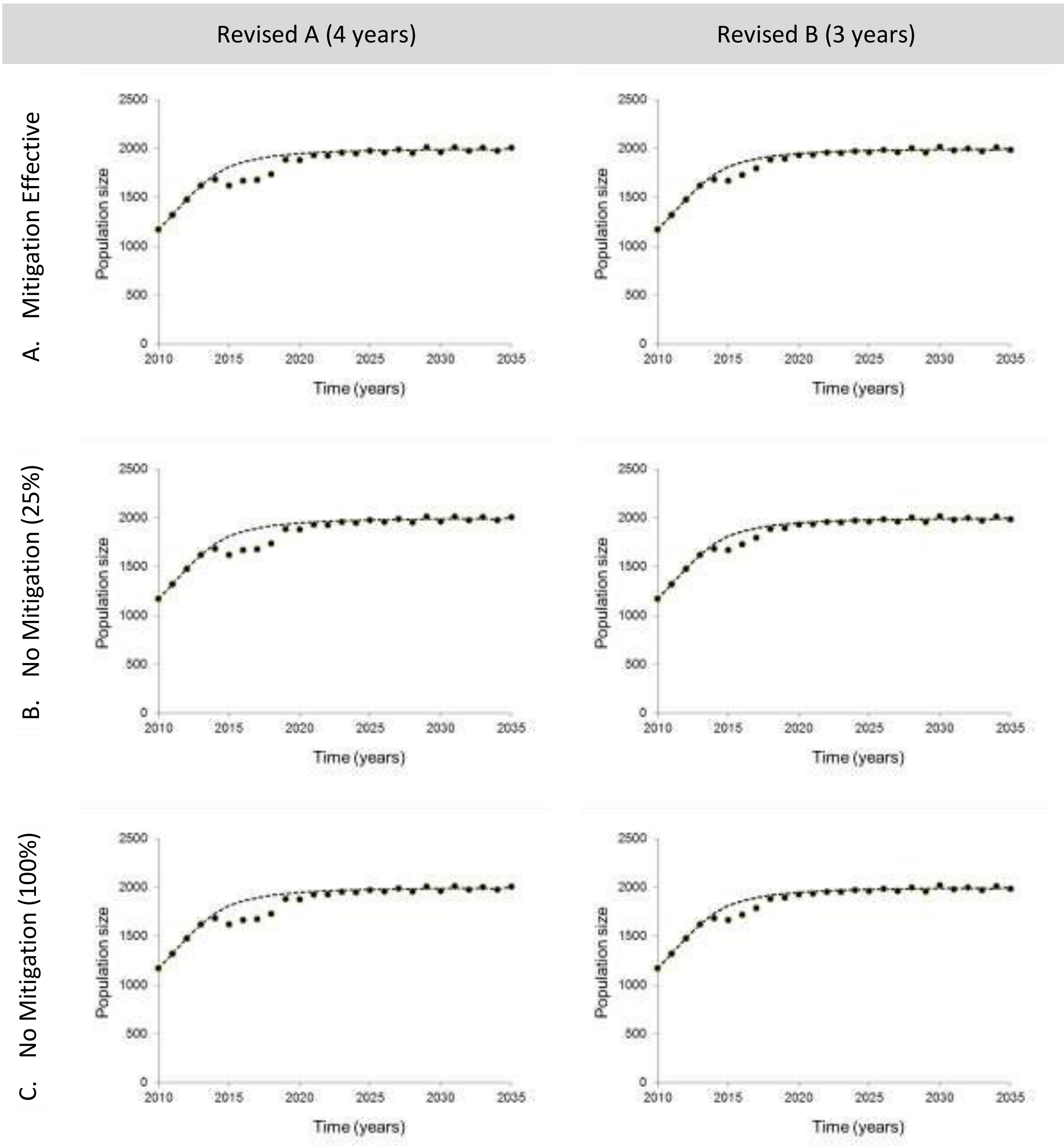
c) Maximum number of first piling strikes in which an individual is likely to be present in each zone (95% Confidence). Data are only presented for those scenarios where the cumulative probability of an individual being present is >0.05 (see Table 5b)

	2m	4m	24m	38m	60m	500m
Harbour Seal	-		2	3	7	208
Grey Seal	-		1	2	4	108
Harbour Porpoise	-	-		6	16	552
Bottlenose Dolphin	-	-		-	-	1
Minke Whale	-	-		1	2	21

Assessing the population consequences of not mitigating instantaneous death and injury for BOWL and MORL Project 1 together

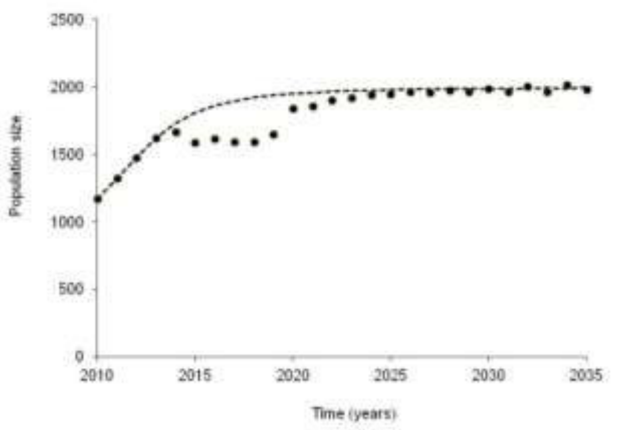
As outlined above, estimates for harbour seals suggest that in the absence of mitigation, there is >99% probability that harbour seals will not be killed during any of the first piling strikes, and a maximum of only seven additional individuals are expected to suffer physical or auditory injury using the larger injury zones (60m) considered in this assessment (Table 1). The impacts of including or not including these additional impacts were explored using the two revised construction scenarios outlined in Table 4, and also by varying the mortality resulting from instantaneous injury between 25% (as used for PTS in the baseline model) and 100% (Figure 2). Inspection of Figure 2 suggests that there is no discernible population level impact from the lack of any mitigation when constructing the BOWL and MORL Project 1 wind farms for either of these construction scenarios, even when all injuries were assumed to result in mortality.

Figure 2. Modelled population trajectories for the two construction scenarios (solid circles) in relation to baseline trends (dashed line) showing patterns with (a) effective mitigation for instantaneous death and injury (b) no mitigation and traumatic injury resulting in 25% mortality and (c) no mitigation and traumatic injury resulting in 100% mortality.

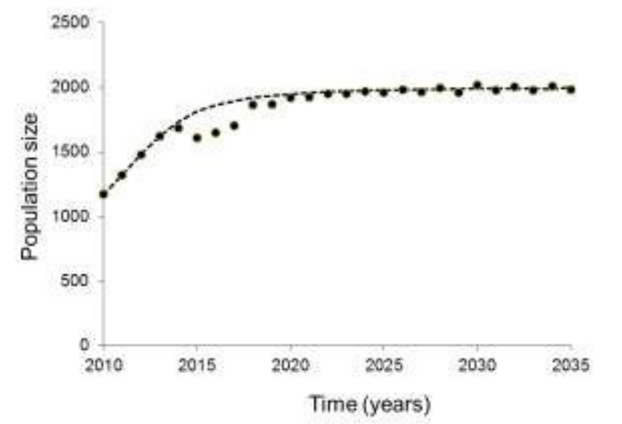


Revised scenario B is presented below in relation to the worst case cumulative assessment from the BOWL and MORL ESs (Figure 3). Assuming 100% reproductive failure and the absence of mitigation for Revised Scenario B, the decrease in population is smaller compared to the worst case scenario assessed in the ESs (Figure 3). Adopting a less conservative assumption for Revised Scenario B, where displacement leads to 50% reproductive failure (a more probable worst case scenario), illustrates that the decrease in population would be smaller again compared to the worst case cumulative scenario presented in the ES (Figure 3).

Figure 3. Comparison of baseline and construction scenarios for the worst case scenario A (from the ES) and Revised Scenario B with no mitigation and 100% mortality from Figure 2. These can also be compared with a further alternative for Revised Scenario B in which the reduction in reproductive success due to displacement is reduced to 50% instead of 100%.

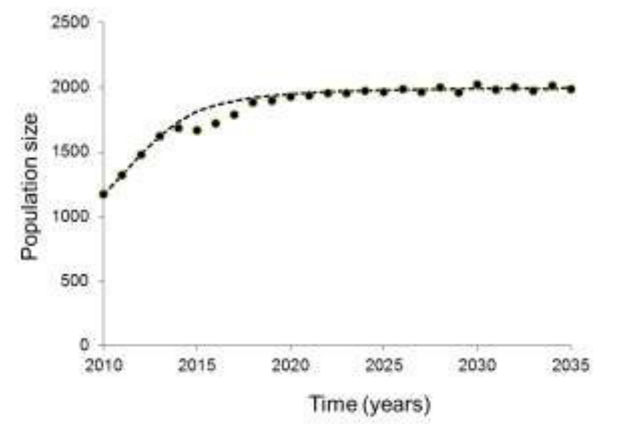


ES Worst Case Cumulative A



Revised Scenario B

100% reproductive failure due to displacement



Revised Scenario B

50% reproductive failure due to displacement

Project specific estimates of marine mammal occurrence within different impact zones at the start of piling sequences

In response to requests from the SNCBs, Table 6 also presents project specific estimates of the risk of different species being present within the 60m instantaneous injury zone, as calculated by Cefas. Here, probabilities are based on the local densities presented in the respective ESs, as summarised in Table 2. The probabilities of occurrence for each species are less than those calculated for the assessment of both projects together (Table 5). On this basis, it can be surmised that there will be no discernible population level impact from the lack of any mitigation when constructing either the BOWL or MORL Project 1 wind farms alone since the construction scenarios for each development alone are considerably less than the scenarios assessed for these two developments together (see Figures 2 and 3). Therefore, even when all injuries are assumed to result in mortality, based on the results of the assessment of both BOWL and MORL Project 1 together, it is considered unlikely that either BOWL or MORL alone would result in a population-level effect.

Table 6. Project specific estimates of the probabilities for each species occurrence within the 60m instantaneous injury zone.

a) Probability of an individual being present within the 60m instantaneous injury zone during the first strike of a single pile

	BOWL	MORL
Harbour Seal	0.00349	0.00339
Grey Seal	0.00141	0.00195
Harbour Porpoise	0.01014	0.00983
Bottlenose Dolphin	<0.00001	0.00001
Minke Whale	0.0002	0.00022

b) Cumulative probability of an individual being present within the 60m instantaneous injury zone at least one of the first piling strikes for BOWL (n=352) and MORL (n=432)

	BOWL	MORL
Harbour Seal	0.71	0.77
Grey Seal	0.39	0.57
Harbour Porpoise	0.97	0.99
Bottlenose Dolphin	<0.01	<0.01
Minke Whale	0.07	0.09

c) Maximum number of first piling strikes in which an individual is likely to be present in each zone (95% Confidence). Data are only presented for those scenarios where the cumulative probability of an individual being present (Table 6b) is >0.05.

	BOWL	MORL
Harbour Seal	3	4
Grey Seal	2	3
Harbour Porpoise	7	8
Bottlenose Dolphin	-	-
Minke Whale	1	1

Conclusions

All stakeholders wish to minimise the likelihood that any marine mammals suffer instantaneous death or injury during offshore piling. Given that these species are expected to move away from loud noise sources, it is accepted that the period of highest risk is likely to be at the beginning of a piling sequence when naïve animals may be close to a piling vessel. Understanding of the noise thresholds that could result in instantaneous death or traumatic injury from a single pulse of this kind is relatively good, and predicted zones in which death or injury may occur (Table 1) are all relatively small for the Moray Firth developments (< 60m). The precautionary nature of the current JNCC guidelines means that MMOs and PAM are required to monitor a much larger 500m mitigation zone around piling activity, with the aim of ensuring that animals are absent from this area before piling can be initiated.

These simulations highlight that, at typical Moray Firth densities, the probability of randomly distributed marine mammals being at risk from instantaneous death or injury at the start of an individual piling event is extremely low (<1%)(see Table 5). In practice, it is likely that the noise coming from vessels during the pile setup would already have displaced individuals out of the immediate danger area, and these values should be even lower. This suggests that, even if mitigation using either JNCC guidelines or ADD failed completely, there are unlikely to be any deaths and a maximum of only 2-16 instantaneous injuries per species during the whole construction programme of the BOWL and MORL Project 1 wind farms. Incorporation of the relevant numbers for seals into the revised scenarios for the Moray Firth Seal Assessment Framework indicate that the absence of mitigation for these near field instantaneous injuries has negligible impact on the resulting population trajectories (Fig. 2).

Notwithstanding these results, it is important to emphasise that they should not be seen as a reason to abandon efforts to mitigate near-field impacts. However, they do provide an evidence base to help balance decisions on the risks of trialling alternative mitigation measures such as ADDs. This framework could also be applied to other developments which have different animal densities or injury zones. Similarly, the approach could be extended for use with other species such as harbour porpoise by considering these injuries as "takes" within a Potential Biological Removal analysis.

Beatrice Offshore Windfarm Ltd MORAY OFFSHORE RENEWABLES

References

1. Bailey H., Brookes K.L., Thompson P.M. 2014 Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. *Aquatic Biosystems* **10**(1), 8.

2. Southall B.L., Bowles A.E., Ellison W.T., Finneran J.J., Gentry R.L., Jr C.R.G., Kastak D., Ketten D.R., Miller J.H., Nachtigall P.E., et al. 2007 Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* **33**, 411-521.

3. Weir C.R., Dolman S.J. 2007 Comparative Review of the Regional Marine Mammal Mitigation Guidelines Implemented During Industrial Seismic Surveys, and Guidance Towards a Worldwide Standard. *Journal of International Wildlife Law & Policy* **10**(1), 1-27. .

4. Thompson P.M., Hastie G.D., Nedwell J., Barham R., Brookes K.L., Cordes L.S., Bailey H., McLean N. 2013 Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. *Environmental Impact Assessment Review* **43**, 73-85. .

5. Parsons E.C.M., Dolman S.J., Jasny M., Rose N.A., Simmonds M.P., Wright A.J. 2009 A critique of the UK's JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best practise? *Marine Pollution Bulletin* **58**(5), 643-651. .

6. Evans P.G.H., Hammond P.S. 2004 Monitoring cetaceans in European waters. *Mammal Review* **34**(1-2), 131-156. .

7. Van Parijs S.M., Clark C.W., Sousa-Lima R.S., Parks S.E., Rankin S., Risch D., Van Opzeeland I.C. 2009 Management and research applications of real-time and archival passive acoustic sensors over varying temporal and spatial scales. *Marine Ecology Progress Series* **395**, 21-36..

8. Brandt M.J., Höschle C., Diederichs A., Betke K., Matuschek R., Nehls G. 2013 Seal scarers as a tool to deter harbour porpoises from offshore construction sites. *Marine Ecology Progress Series* **475**, 291-302.

9. Brandt M.J., Höschle C., Diederichs A., Betke K., Matuschek R., Witte S., Nehls G. 2013 Far-reaching effects of a seal scarer on harbour porpoises, Phocoena phocoena. *Aquat Conserv Mar Freshwater Ecosys* **23**(2), 222-232.

10. Wade P.R. 1998 Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. *Marine Mammal Science* **14**(1), 1-37.

11. Thompson P.M., Mackey B., Barton T.R., Duck C., Butler J.R.A. 2007 Assessing the potential impact of salmon fisheries management on the conservation status of harbour seals (Phoca vitulina) in north-east Scotland. *Animal Conservation* **10**(1), 48-56..

Annex. Summary of key assumptions made within the framework.

1. **The objective of mitigation during the piling process is to minimise the risk of instantaneous death or injury during the initial piling strikes, not to reduce potential impacts from cumulative noise exposure or disturbance**.

2. **Individuals of each species are randomly distributed across the development site at the densities reported within the BOWL and MORL ES's.** This will be a simplification due to spatial variation in habitat quality and, for some species at least, social behaviour. The former should balance out across the sites when considering cumulative probabilities (Table 5b), but assessments could be re-run using minimum and maximum densities to assess how individual probabilities (Table 5b) vary between sites.

3. **Estimates of the cumulative probability of animals occurring in particular impact zones assume that all piling events are independent.** In reality, piling events will be clustered in groups of 4, with longer intervals between events at different turbine sites. Thus, it is more likely that disturbance during the first piling event at each turbine site will reduce the probability of animals being within the injury zone during the next three piling events.

4. **The revised project design for BOWL's construction scenario, as presented in the Piling Strategy, assumes that piling will involve a single vessel working over a maximum 1.5 year period. MORL's development details are still to be finalised, but here it is assumed that MORL Project 1 will also involve a single vessel working over a 2 year period.** Additional piling vessels may be required particularly in case of delays in construction programme, in which case this increase in the intensity of disturbance would result in concurrent reductions in the overall duration of disturbance. Piling at BOWL may be completed within two spring/summer seasons, reducing potential impacts of disturbance on reproductive success.

5. **To model the population consequences of instantaneous death or injury, it was assumed that mortality rates from injury from PTS resulted in either 25% mortality (eg. Fig 2b) or 100% mortality (eg. Fig 2c).** Recent use of Southall et al.'s (2007) M weighted PTS threshold for cumulative noise exposure suggest that ~ 50% of this rapidly increasing harbour seal population may have been at risk of PTS (Hastie et al. 2015). This suggests either that this pinniped PTS threshold is conservative, or that the risk of mortality from PTS is lower than the values used here.

6. **All other assumptions in the population model were the same as those used in the Moray Firth Seal Assessment Framework (Thompson et al. 2013).** The only exception is the final panel in Figure 3, where the impacts of behavioural displacement were reduced to a 50% reduction in reproductive success. This is now likely to represent a more realistic worst case given a) reductions in turbine numbers and the potential to focus piling over the summer season rather than maintain piling intensity throughout the whole annual cycle and b) emerging evidence from DECC SEA funded studies in the Wash that Harbour Seals were not displaced over the whole construction period, and continued to use preferred areas between piling events.

Annex Refs:

Hastie, G.D., Russell, D., McConnell, B., Moss, S., Thompson, D. & Janik, V.M. (2015) Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage. *Journal of Applied Ecology* 52, 631-640.

Thompson P.M., Hastie G.D., Nedwell J., Barham R., Brookes K.L., Cordes L.S., Bailey H., McLean N. 2013 Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. *Environmental Impact Assessment Review* 43, 73-85.

Southall B.L., Bowles A.E., Ellison W.T., Finneran J.J., Gentry R.L., Jr C.R.G., Kastak D., Ketten D.R., Miller J.H., Nachtigall P.E., et al. 2007 Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33, 411-521.